PUBLIC WORKS

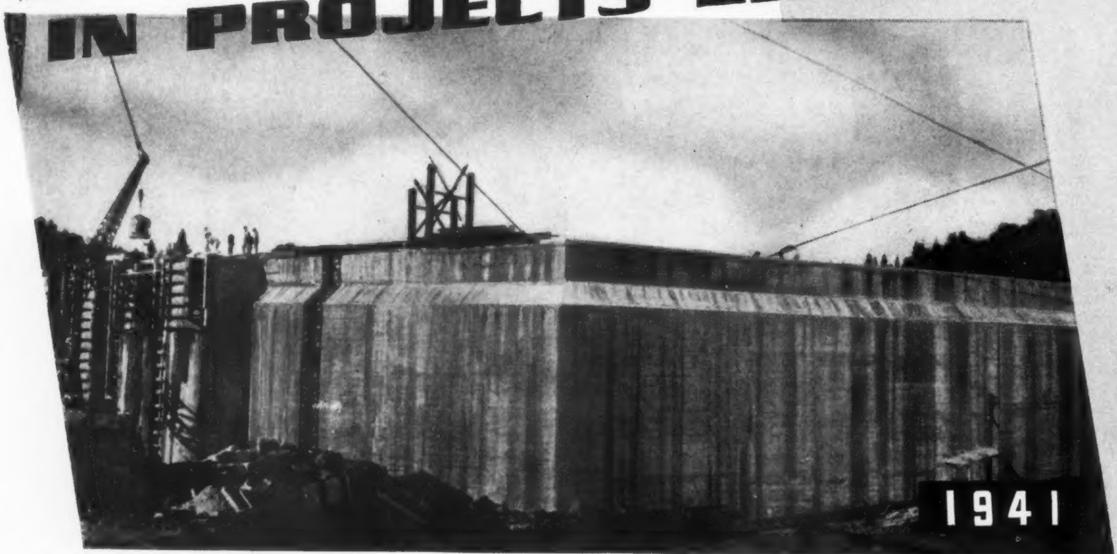
Performance LIKE THIS..

One of many convincing reports received from leading railroads:

July 14, 1942—"Experience over a seven-year period shows that Pozzolith produces increased workability and easier placeability, even though we reduced mixing water as much as 15-20%. A noticeable decrease in segregation defects enabled us to finish the concrete faster and at a lower cost. Regular inspections indicate that the concrete in which we used Pozzolith has higher durability because to date we have no knowledge of maintenance expense on any of the concrete where this material was used."

ERIE RAILROAD COMPANY
Engineering Department

HAS RESULTED IN THE USE OF POZZOLITH (CEMENT DISPERSION) IN PROJECTS LIKE THIS..



Greater durability, of paramount importance in building important projects like this dam of Mac Laren-Quebec Power Company, has been demonstrated time and again in the performance of Pozzolith concrete.

Speed, another vital factor in today's construction program, results from the easier placeability, earlier stripping of forms and faster finishing made possible with Pozzolith.

Cement Dispersion—important technological development—is helping deliver war materials sooner . . . saving millions of ton-miles of vital transportation space . . . reducing cost of construction . . . producing concrete of unusual strength and durability.

The *dispersion* principle, responsible for modern developments in synthetic rubber, plastics, steel, ceramics and many other basic materials now brings important benefits to all concrete.

Used in over four million yards of concrete since 1932, Cement Dispersion has demonstrated its ability to meet today's construction demands—speed, economy, durability.

Research Papers No. 36—"Economics of Cement Dispersion" (for mass concrete) and No. 39—"Cement Dispersion and Air Entrainment" (for runways and pavement), also illustrated Pozzolith booklet sent upon request.

THE MASTER BUILDERS COMPANY

CLEVELAND, OHIO **TORONTO, ONTARIO**

MASTER BUILDERS

THE WAR EMERGENCY

Scrap From Public and Domestic Sources

The drive for scrap seems to be exceeding expectations, but these were far below the necessity. One New Jersey town of 45,000 set its aim at 100 tons, and has already collected over 1,000—over 40 lb. per capita in a purely residential suburb. Middletown, O., with manufacturing industries, where the American Rolling Mill Co. and the town salvage committee are cooperating, is collecting 50 tons monthly. Omaha, Neb., has collected 104 lb. per capita.

The minimum amount of iron and steel scrap needed to keep steel production up to capacity through the winter is 17,000,000 tons, or 260 lb. per capita. But a considerable part of this is being obtained from industrial establishments, under the policy "If it hasn't been used for three months and if no one can prove it can be used in the next three—find a use for it or scrap it."

Scrap from the general public can be secured only by community effort. Each city, town and village should organize for its collection. Also each should investigate its own corporate property—the equipment and stock yards of the highway, water, sewer and other departments; the public buildings (Pittsburgh, Pa., found more than 100 tons of old iron fire escapes on abandoned school buildings); out-of-service street rails, bridges, iron railings, "eye-sore" statues, etc. City and consulting engineers can help here, for they probably know better than any one else where this kind of scrap can be found. County and state highway engineers also may be able to locate large amounts of damaged forms, antiquated equipment and worn-out tools to help fill this vital need.

Restrictions on Bituminous Materials

On October 5 the Petroleum Coordinator issued an amendment to the restrictions on the use of asphaltic and tar products for road work (see "The War Emergency" for July), extending its application of restrictions throughout the United States. These apply to "the use of asphalt or of any asphaltic product, including road oils, or of tar or any tar product, in the construction, reconstruction, paving, surfacing or resurfacing and in the maintenance or repair, of any public road, street, highway or driveway, or public parkway" in all of continental United States; "except in the case of public roads, streets, highways or driveways, or public parkways, certified by the Public Roads Administration of the Federal Works Agency to be necessary to the successful prosecution of the war, and for the construction, reconstruction, paving, surfacing or resurfacing, and for the construction, or the maintenance or repair, of which the Public Roads Administration certifies that the use of asphalt or an asphaltic product (not including road oil) or tar or a tar product, is essential." Nor shall such material be used for any other paving or surfacing except as approved by the Director of Marketing, Office of Petroleum Coordinator; except that no approval is required for airports, aircraft plants, or surfaces within buildings. If possible, these materials must be transported by tank trucks for all distances of 200 miles or less.

However, where, in the area not included under the original restriction, equipment and material has been placed on the location on or before October 5, its use is permitted until October 15, but not thereafter except upon certification by the Public Roads Administration or the Director of Marketing. Use of road oils shall cease after October 25.

Bureau of Priorities Control

On September 29, J. A. Krug, Deputy Director General for Priorities Control, announced the organization of the Bureau of Priorities Control. It will comprise four divisions with a total of 15 operating branches, an Appeal Board and a Clearance Committee. The four divisions are: Materials Control Division, Priorities Review Division, Compliance Division, and Foreign Division. The operating branches will attend directly to the processing of applications for priority assistance, which should save time in obtaining action on them.

Registration of Construction Equipment

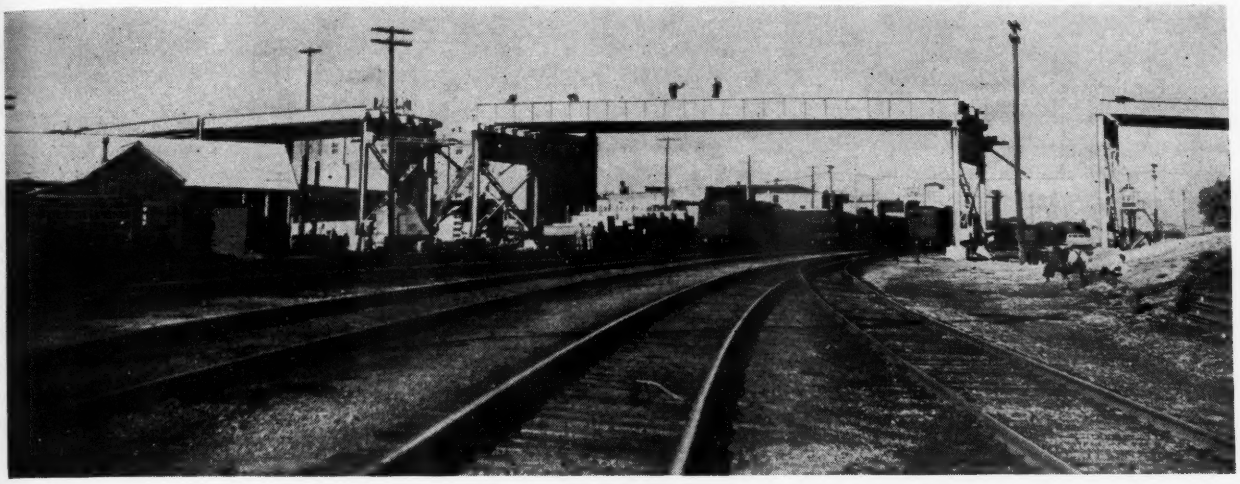
In "The War Emergency" for September we called attention to the WPB order that every owner of used construction equipment register it with WPB on or before September 30. It was at once evident that the time allowed was altogether too short and it has been extended to October 31. Equipment must be registered on form WPB 1159, copies of which can be obtained at any WPB regional office or from the Used Machinery Specialists.

Purchasing Officers Needed

The government urgently needs purchasing officers to prepare specifications and bidding blanks for the purchase of government supplies, and maintain current information as to market trends, sources of supply, and laws and regulations. Applicants should have had 2 to 6 years of responsible experience as purchasing or procurement officer for a railroad or other public utility, a large industrial or commercial establishment, a branch of the Federal government or that of a State or large municipality. Applications are not sought from persons engaged in war work unless a change of position would result in utilization of higher skills possessed by the applicant; nor from those engaged in any production and maintenance occupations in connection with non-ferrous metals, nor those in logging and lumbering industries in the far west. There are no age limits; no written tests. Salaries, $2,000 to $4,600 a year. Application forms may be obtained at any first-class or second-class post office or from the Civil Service Commission, Washington, D. C.

PUBLIC WORKS Magazine . . . OCTOBER, 1942

VOL. 73. NO. 10



"A" Street overpass during process of erection.

Rock Springs, Wyoming, Subway-Viaduct Project

By DAVID P. MILLER

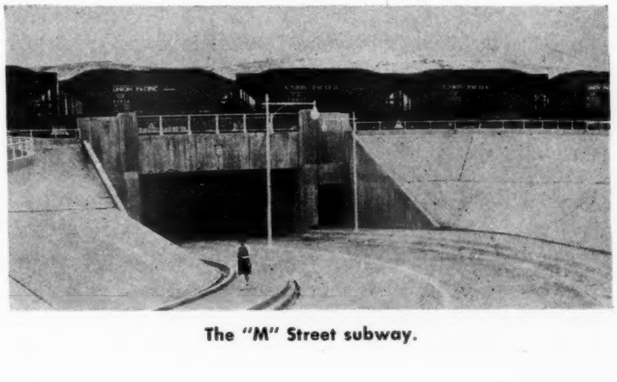
Construction by city and railroad, with Federal aid, of an underpass, an overpass and a subway to terminate an intolerable interference with crossing traffic. Absorptive concrete form lining used.

THE City of Rock Springs, Wyoming, which has a population of about 10,000, is the center of the coal-mining field which supplies the bulk of the railroad coal consumed by the Union Pacific Railroad. It is situated on both sides of the Union Pacific main line, which divides the city in two almost equal parts. In addition to the double track main line, the railroad maintains an extensive yard system used for the handling of the coal traffic. In peak periods of the railroad business there have been as many as 90 main line train movements across the only crossing available, together with innumerable switching movements, which created an intolerable situation, not only from the standpoint of vehicular traffic seeking to use the crossing but also to the railroad company, which suffered much delay due to cramping of its traffic movement.

For several years, effort had been made to eliminate the grade crossing at "C" Street, but, due to conflicting interests among the business men of the city, nothing had been accomplished until 1940, when the situation had become so bad that everyone realized that selfish interests had to be abandoned. The United States Government made available about $350,000 from the Grade Crossing Elmination Fund, and a bond issue was voted by the city in the amount of $75,000 to cover the cost of the right of way and the paving of the necessary streets which were connecting the structures. The Union Pacific Railroad Company prepared the plans for the construction of the structures and also handled the details involving the relocation of certain of its tracks.

After a traffic survey had been made, it was decided that three structures would be necessary; a vehicular underpass at "M" Street; a vehicular over-

(Continued on page 70)



The "M" Street subway.

The Operation of Sewa

For their valued help and advice in preparing this text, the publishers of PUBLIC WORKS are indebted to those men whose names are listed below, and also to numerous others who contributed suggestions and material. A mimeographed preview copy was sent to each of them and the hundreds of resulting suggestions have been used by us in giving the text its completed form as published in this issue.

F. E. DANIELS, Pennsylvania State Department of Health; FLOYD G. BROWNE, Consulting Engineer; W. H. WEIR, Major, Sanitary Corps, U. S. Army; JOHN T. NORGAARD, Associate Sanitary Engineer, Corps of Engineers, U. S. Army; A. J. FISCHER, The Dorr Co.; M. B. TARK, Link-Belt Co.; S. L. TOLMAN, The Jeffrey Mfg. Co.; H. W. GILLARD, Infilco, Inc.; H. J. GRAESER, JR., 1st Lt., Sanitary Corps, U. S. Army; J. J. GILBERT, Major, Sanitary Corps, U. S. Army; L. W. TRAGER, Capt., Sanitary Corps, U. S. Army; J. J. MILLER, Capt., Corps of Engineers, U. S. Army; ARTHUR TOMEK, Office of The Chief of Engineers, U. S. Army; K. C. LAUSTER, Acting Director, Division of Sanitary Engineering, North Dakota; HERBERT M. BOSCH, Capt., Sanitary Corps, U. S. Army; V. M. EHLERS, State Sanitary Engineer, State Department of Health of Texas; L. K. CLARK, Capt., Sanitary Corps, U. S. Army; A. S. BEDELL, State Department of Health, New York; F. C. DUGAN, Major, Corps of Engineers, U. S. Army; F. H. WARING, Chief Engineer, Ohio State Board of Health; JAMES B. LACKEY, Biologist, U. S. Public Health Service.

FOUR years ago last month PUBLIC WORKS issued the first comprehensive text on this subject, designed to provide a foundation of knowledge "for the average operator on which he may build further by his own efforts and in cooperation with his State Department of Health." The many thousand copies of that text that were distributed testify to its practical value.

Today the situation is changed. This nation is engaged in a great war, which has already drawn heavily on its resources of men and materials. State Boards of Health are faced with hosts of new problems brought about by the location of industrial plants or army camps within their limits, and are, at the same time handicapped by the loss of a great proportion of their skilled personnel. Materials and equipment are difficult or impossible to get. The operator this year and for an uncertain future period must (a) make his present equipment do "for the duration" and (b) rely upon himself, the engineering magazines and technical text books to learn to do his job better than before.

There is yet another factor. Sewage plant operators, like men in every other walk of life, have felt the urge and have joined our armed forces in large numbers. Others have been called upon to operate the hundreds of Army and Navy plants scattered throughout the nation. Their places have been taken by junior operators.

To provide greatest usefulness, this text has been revised to meet wartime conditions. Emphasis is placed on (a) instructional material for new operators and (b) how to care for and keep equipment now in use in working order until that happy day when the war is won.

I.—The Real Job of the Sewage Plant Operator

1. It is essential to understand fully "why" a sewage treatment plant and "what" the functions of an operator are. An appreciation of his duties will help him to a better realization of what he should know in the technical field and in what ways he can best employ his initiative and common sense.

2. A sewage treatment plant is constructed to protect health and prevent nuisance. Sewage may contain the germs of various diseases that are transmissible through water. The contamination of streams by sewage may therefore cause disease in persons drinking or even swimming in the water. Milk cows wading in a stream containing sewage may result in contamination of the milk during the milking process. There are innumerable other methods by which the so-called filth-borne diseases (commonly typhoid fever, paratyphoid, dysentery and diarrhea) may be spread through the medium of water.

Perhaps a more common reason sewage treatment plants are built is to eliminate nuisance and odor and avoid damage suits. Everyone knows that the discharge of raw sewage into a small stream creates nuisance. If enough of the putrescible organic matter is removed from the sewage, it will not cause undesirable conditions in the stream. The accomplishment of this objective is an important aim in sewage treatment plant operation.

3. *What the Operator Should Do*—The operator's job is to get the most that it is possible to get out of the community's investment in a sewage treatment plant in terms of nuisance prevention and health protection. A sewage treatment plant represents a large investment of public funds and it is the operator's job to protect that investment and make it yield the greatest dividend in satisfaction and health protection. The plant should receive even greater care than any other investment made by the city because it performs a more important function than almost any other city structure, such as a new city hall or a new street.

The plant should always be kept in an attractive condition. Grounds should be cleanly mowed, shrubs and flowers should be planted, and structures and equipment should be painted, both for protection and for appearance.

The operator may be responsible for the direction and management of several plant employees.

eatment Plants

Second Revised Edition

A comprehensive text for the average operator, brought up to date and revised to meet wartime conditions, including the necessity of training new operators to meet the increased demand for them.

TABLE OF CONTENTS

The duties of an operator, therefore, may be classed under the following general heads:

(a) To see that all operating details are performed promptly and efficiently. Normally this is best accomplished by establishing a routine schedule of operation, with each employee assigned to a definite task.

(b) To make necessary analyses of the sewage as it passes through the plant and of the effluent to determine the efficiency of operation of the plant and to maintain the proper records of operation.

(c) To maintain the sewage plant equipment and structures in good condition.

(d) To insure that necessary safety precautions are observed to protect both personnel and property.

4. *Results*—The final basis on which sewage treatment plant operation is judged is the condition of the waters into which the plant effluent is discharged. Regular samples should be taken, preferably every week, of the stream waters above and below the point of discharge as well as of the plant effluent. Records of these should be maintained at the plant to show the condition of the receiving stream.

Fig. 1. At the left is a scale by which Fahrenheit and equivalent Centigrade temperatures may be read directly.

Fig. 2. At the right is an Imhoff Cone, essential in making tests for settleable solids.

II.—Methods and Units of Measurement

1. *General*—In sewage plant operation, including the performance of tests, several methods of measurement are or may be employed. The metric system is universally used in all laboratory work, but the standard unit of flow is the gallon.

2. *The Metric System*—In the metric system the basic unit of volume is the liter, which is slightly more than 1 quart (actually 1.05 quarts). This is equal to 1000 cubic centimeters, and also to 1000 milliliters; the cubic centimeter is the same as the milliliter. The unit of weight is the gram, which is the weight of 1 cubic centimeter or 1 milliliter of water under standard conditions. The milligram is one-thousandth of a gram, that is 1000 milligrams equal 1 gram. Therefore 1 liter weighs 1000 grams or 1,000,000 milligrams. The weight of a gram is about one-thirtieth of an ounce; a kilogram, which is 1000 grams weighs about 2.2 pounds.

The operator should be accustomed to use the metric system in all of his laboratory work, as it is much handier and it is used in most literature on the subject.

The following abbreviations are commonly employed: Liter, *l.;* cubic centimeter, *cc.;* milliliter, *ml.;* milligram, *mg;* gram, *g.;* kilogram, *kg.*

Most or all laboratory apparatus is graduated to cc. or ml.; and laboratory balances weigh in grams and milligrams.

3. *Measurements*—The amount of solid matter in sewage, or the dosage of chemicals, such as chlorine, is preferably expressed in parts per million, abbreviated ppm. In the metric system, 1 mg. to a liter is equivalent to 1 ppm.; 3 mg. per liter is 3 ppm. In the common system of measurement, 1 pound in a million pounds is 1 ppm. A gallon of water weighs 8.33 pounds; a million gallons weigh 8,330,000 pounds. A dosage of 1 ppm. of, say chlorine, is 8.33 pounds per million gallons. Stated in the reverse order 8.33 pounds per million gallons is 1 ppm.; 16.66 pounds per million gallons are 2 ppm. (or 2 milligrams per liter).

A third way of stating dosages, not much used in

(Continued on page 25)

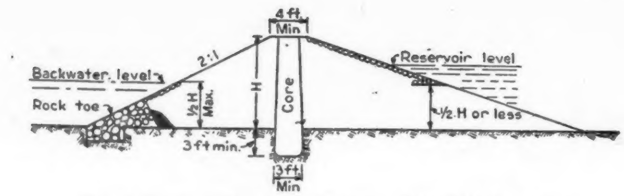


Fig. 3. Cross section of earth dams 12 feet high or less.

Earth Dams

THE design of an earth dam is controlled to some extent by the site and the materials available there or nearby for constructing it.

a. Selection of Site.—In selecting the site for a small earth dam, there are other factors to consider than the finding of that location which will require a minimum of earth for construction. Very important are the underground conditions, since these may determine if excessive percolation will defeat the purpose for which the dam is intended, or may even cause its failure. Equally important is a safe and adequate spillway. Consider also the proximity of suitable materials and balance the cost of these in place in the dam against the volume required. A site requiring more materials which however are close at hand and capable of economical handling may prove cheaper in the end. Investigations should be made to determine if crawfish, muskrats or other burrowing animals may damage the dam.

b. Design Essentials.—(1) The spillway must have sufficient capacity to pass the maximum flow; (2) overtopping by wave action at maximum high water must be prevented; (3) the original height of the dam must be sufficient to provide a safe freeboard after settlement; (4) the foundation must be capable of bearing the weight of the dam; (5) the materials of which the dam is built must be dense enough to prevent any dangerous flow of water through it; (6) the embankment must be stable at all times; and (7) erosion of the embankment by surface runoff must be prevented.

c. Design Procedure.—Assuming that the required spillway capacity and the elevation of the spillway crest have been selected, (1) determine the cross-section, making allowance for shrinkage and settlement; (2) determine maximum load on the foundation and the bearing strength of the weakest stratum; there should be a factor of safety of at least 1.5; (3) consider the permeability of the foundation and the need for a cutoff; (4) decide on the type of diaphragm or core and select materials for it; (5) determine the need for toe drains; and (6) after studying the material of which the dam will be built, decide on the necessity for using selected materials and for moisture control during compaction. These factors will now be discussed.

d. The Profile or Section of the Dam.—It is common practice to make upstream slopes 3:1 and downstream slopes 2:1 or 2½:1. More depends upon the material than on any other factor, once the minimum profile for safety is reached. The line of saturation of the water passing through the dam must be kept within the downstream face to prevent sloughing or sliding of the slope. Coarse materials on this face will therefore be safer with a steep slope than will fine materials. This question of slope is also dependent upon the importance of the dam, and on other factors which will be mentioned later. Indeed, so many of the important factors in dam design are so closely related and so mutually interdependent upon each other that it is not sufficient to consider slope entirely by itself.

On dams over 15 or 20 feet high, berms should be placed at vertical intervals of 15 feet or so. Gutters may be placed in these to carry off storm water. In addition to minimizing the erosive effect of storm water, berms add to the stability by widening the base.

Drainage of the dam itself (since even the best built earth dams pass some seepage) is accomplished by placing the coarser materials in the downstream half, or by building the toe of loose stone, or by a system of drains in the dam; or in some dams by all three methods.

Figs. 3 and 4 show two forms of earth dam, the latter with a berm. Both are somewhat defective in showing a smooth and level joint between the dam and the earth. Referring to Fig. 3, the entire area covered by the dam should be plowed. In Fig. 4, in addition to plowing, a trench should be excavated, about 4 ft. wide and 4 ft. deep under the center line of the dam, and backfilled with selected material, well compacted.

e. Freeboard.—On a small lake, wave action will be insignificant; where the wind has a sweep of a mile, waves 3 feet high may be expected at infrequent intervals. These may occur at the time of maximum flow over the weir. Compute the maximum flood to be expected, and from the spillway length determine the depth of flow necessary to pass this flood. Add the allowance for wave action and a margin of safety. On dams 25 feet high, for instance, there should be at least 1 foot freeboard above any expected wave action, when the spillway is passing the maximum probable flow. Top width is important too in reducing damage from high waves.

The Stephenson formula, especially applicable to larger reservoirs, is

$$h = 1.5\,D^{1/2} + 2.5 - D^{1/4}$$

where h is the expected maximum height of wave from trough to crest and D is the length of water, in miles, exposed to the wind. For a reservoir 2 miles long, the wave height would be

$$1.5 \times 1.41 + 2.5 - 1.2 = 3.4 \text{ ft.}$$

f. Frost Action.—Frost may weaken the top portion of the dam. Therefore a minimum freeboard should be provided for a safeguard against freezing and thawing. A common value is 3 ft. Since the freeboard is usually greater than this, special provisions will rarely be necessary.

g. Top Width.—For earth dams generally, the top width should be approximately 20% to 25% of the height of the dam. A safe rule is 20% of the height plus 5 feet. This will care for all average cases and pro-

nt

Designing Low Dams—II.

Selecting the site. Designing the dam, its core walls, toe protection, spillway and outlet. Selection of embankment materials. Preparing the foundation.

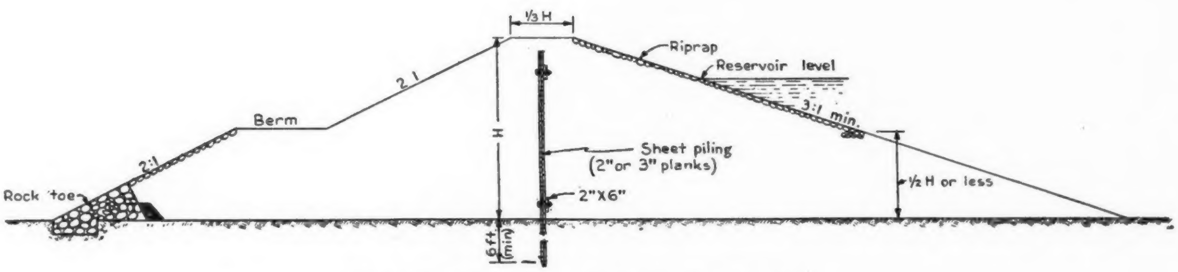


Fig. 4. Cross section of earth dams 12 to 20 feet high.

vides a starting point for determining unusual needs. Figs. 3 and 4 show dams that are perhaps deficient in top width. The formula $W = 2 H^{1/2} + 3$ is used, where W is top width and H is maximum height of embankment in feet. For a 25-ft. high dam, $W = 2 \sqrt{25} + 3 = 13$ ft., whereas $0.2 H + 5$, stated above, provides a 10-ft. width. Either is safe and satisfactory.

h. Shrinkage.—In all consideration of freeboard and profile dimensions, make adequate allowance for shrinkage. In levee construction, material placed with a dragline will settle 20% to 25%, part of which is due to settlement of the soil under the levee. Material placed with tractors and crawler wagons, or with horses and scrapers, will settle around 15%. Earth placed in a dam in 6″ or 8″ layers, with properly controlled moisture content (of which more later) and compacted with a sheepsfoot or other suitable roller, will settle very little, but the earth on which it is placed may compact under the weight of the dam. A properly built rolled dam 25 feet high on a very firm foundation should not settle more than an inch, but a carelessly built one may settle as much as 6 inches.

i. Core Walls and Diaphragms.—Some type of core wall or diaphragm should be used, except in the case of very small dams. What type is used depends upon the preference of the engineer and the materials available locally. Normally core walls will be of concrete, timber or clay puddle. A stone wall laid up in cement mortar, or steel plates may be used.

It should be noted that the use of a core wall changes the character of the dam. A dam without a watertight curtain of this sort—the Mississippi levees, for instance—functions by offering a resistance to the flow of water between the soil particles. This friction or resistance, in the case of a properly built earth dam, so reduces the velocity of flow of the water through the dam that no injury results, that is, no material is carried away and no important amount of water is lost. In such a dam the surface of the percolating water will always be well within the downstream face of the dam.

In a dam with a tight core wall, as concrete, steel, masonry or wood, the earth upstream from the core wall becomes saturated with water and a head is built up on the core wall equal to the head of water behind the dam. Therefore, if a crack or hole develops in the core wall, the head of water above this point tends to force water through the opening. Then, if the material below the core wall is not sufficiently porous to carry away the water passing through the opening, a dangerous condition may develop.

Strictly speaking, a dam of this type is a masonry dam with earth on the downstream face providing the mass to resist the overturning movement due to the water pressure. The upstream embankment prevents overturning of the wall, due to the pressure of the downstream embankment, when the reservoir is empty.

The diaphragm should be carried well below any porous strata, and normally to a depth of at least 6 feet for a dam retaining 12 feet of water. For higher dams, the depth should be increased, depending on subsurface conditions as revealed by test pits. When boulders are present, which may interfere with driving the piling, a trench should be carried down to the desired depth and a selected clay backfill tamped in place moist.

Wooden Diaphragms.—A double row of wood sheet piling should be used where burrowing animals present a problem, and represents good practice at all times. Such construction is shown in Fig. 4, and the details of the piling are shown in Fig. 5. Good timber 2 ins. thick should be used, and the planks should be staggered and securely bolted together. This should be carried down through shallow underlying porous strata, as already stated; it should extend upward to about 1 foot above the maximum height of water with the spillway carrying its maximum flow.

Horizontal longitudinal walls or braces should be placed at about 6-ft. intervals, and all planks bolted to these.

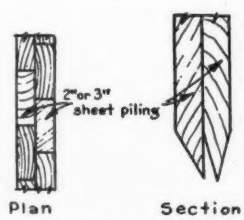


Fig. 5. Details of timber sheet piling.

Creosoted timber is preferable, but not necessary. A good quality material, true and free from cracks and knots, should be used.

Puddle Core Wall.—A trench should be dug for the core wall, as shown in Fig. 3, and the wall should be carried up 2 to 4 ft. above high-water with full spillway discharge. The thickness of a puddled core wall at any point should be not less than one-third the height of the dam above that point. That is, for a dam 18 ft. high, it should be 6 ft. thick at the base and 3 feet thick half way up. At the top it should be at least 2 feet thick.

While further information is given hereafter in regard to earth dam materials, the core should be constructed of specially selected clay, silt and sand, in such proportions and with sufficient moisture to give a dense mixture. This should be compacted carefully. Even when built in this manner, earth core walls are not fully resistant to burrowing animals.

The earth core wall is not well adapted to placement on rock, and when an earth dam rests on a rock foundation, a concrete core wall is preferable.

On small dams, air or gas-operated compactors, or sheepsfoot rollers should be used for compacting the core wall. On large dams, sheepsfoot rollers and large tractors are normally used, and strict quality and moisture control maintained.

Concrete Core Walls.—Core walls of concrete should be based on firm material. If on rock, a trench should be blasted into the rock and the rock cleaned to provide a good tie with the concrete. The concrete core wall should reach to or just above highest water level. The thickness at the top should be at least 1 ft. The thickness at the base will depend on the height of the dam, but will ordinarily be 4 to 6 ft. for a dam 25 or 30 ft. high. The wall should slope with a uniform batter from top to bottom; steps in the wall should be avoided. Light reinforcement is desirable—at least temperature reinforcement. The concrete should be of good quality and the wall free from holes or honeycomb.

Other Types of Core Wall. — Steel plates, rubble masonry laid in cement or similar materials may be used. The same principles apply in all cases: Extension downward to an impervious stratum; extension upward to or above high water; and relative watertightness.

Location of Core Wall.—Normally the core wall is placed under the center of the top of the dam, but may be placed at the upstream edge of the flat portion of the top.

j. Protection for Earth Dams. — The downstream slope of the dam should be protected with a rock toe and riprapped, as shown in Figures 3 and 4. Collecting drains may be used to drain the downstream face, to dry out wet foundations and prevent saturation of the downstream toe. Berms may be desirable on larger dams.

If the reservoir covers more than two or three acres of area, an earth dam should be protected against wave action. This generally should be confined to rock riprap, which is also placed on the downstream face of the dam, as shown in Figures 3 and 4. If no large stones are available and there is an adequate supply of coarse gravel, good protection can be obtained by placing a 12" to 24" layer of this on the slopes of the dam.

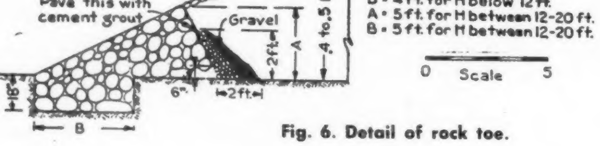


Fig. 6. Detail of rock toe.

The type of protection necessary for the downstream face and toe of the dam depends upon the foundation, height of dam, and height and duration of backwater, if any. A triangular ridge of rock having a height of 3 or 4 feet (see Fig. 6) should be constructed. This rock protects the downstream toe from sloughing off. This protection is especially desirable where there are backwater eddies against the downstream toe of the dam. By paving the inside face of the rock toe, as shown in Fig. 6, dirt from the dam will be prevented from washing down the slope and filling the rock voids. An opening of at least 6 inches next to the ground should be left without grouting in order to permit the seepage water to drain freely. The rock toe should be backfilled with gravel and sand to act as a filter, as shown in Fig. 6, thus preventing any large amount of earth from washing through the toe.

Riprap may be laid on the downstream slope. Protection of the top of the berm with riprap may be required. When designing the spillway, an attempt should be made to deflect the currents away from the downstream face of the dam to minimize the effect of eddies. The drainage of surface water from the slopes of the dam and from adjacent banks should be planned so as to prevent erosion. Where considerable surface water is concentrated after rains, it is advisable to pave with rock the channels which it naturally follows. The top and downstream slope should be either sodded or seeded.

k. Outlet Structures. — It is usually necessary to carry one or more outlet pipes through the dam. These should be placed in trenches dug in the original soil, and carefully backfilled. It is usually better to place concrete under these pipes and backfill around and over them with concrete. Cut off collars should be placed at intervals, these extending a foot or more out from the pipe, in order to prevent the water from following along the pipe. If a concrete core wall is used, there is less need for the collars, care being taken to get a good connection between the pipe and the core wall.

If the pipe is under pressure in the interior of the dam, a break in the pipe is likely to cause failure of the dam. It is therefore desirable to have the control gates at the upstream edge of the dam, and this may be accomplished by a tower at the upstream toe of the dam or by a well or tower in the upstream portion. It may be desirable to arrange the outlets so that water may be drawn from various levels, and the tower or well provides for this.

A concrete or other culvert may be built to carry the water from the stream through the dam during construction and then used later as a pipe gallery. It will provide space for one or more lines of pipe and thus prevent damage from broken pipes. Collars should be built around the culvert to prevent flow along it, and in constructing it the precautions outlined just above for pipes through the dam should be followed.

In sizes up to 16-inch or 18-inch, gate valves are satisfactory for controls; above these sizes, iron sluice gates are cheaper and better for all practical purposes.

l. The Spillway.—Data on capacity and similar factors have already been given. This section will refer to location and construction details. Whenever possible, the spillway of an earth dam should be a separate structure from the dam itself. In locating the site for the dam, consideration should be given to good spillway facilities. Where rock formations exist, a spillway

(Continued on page 68)

Showing the effect of a passage of the cutting machine.

Smoothing Corduroyed Roads in Springfield, Mo.

By L. A. WEEKS
City Engineer, Springfield, Mo.

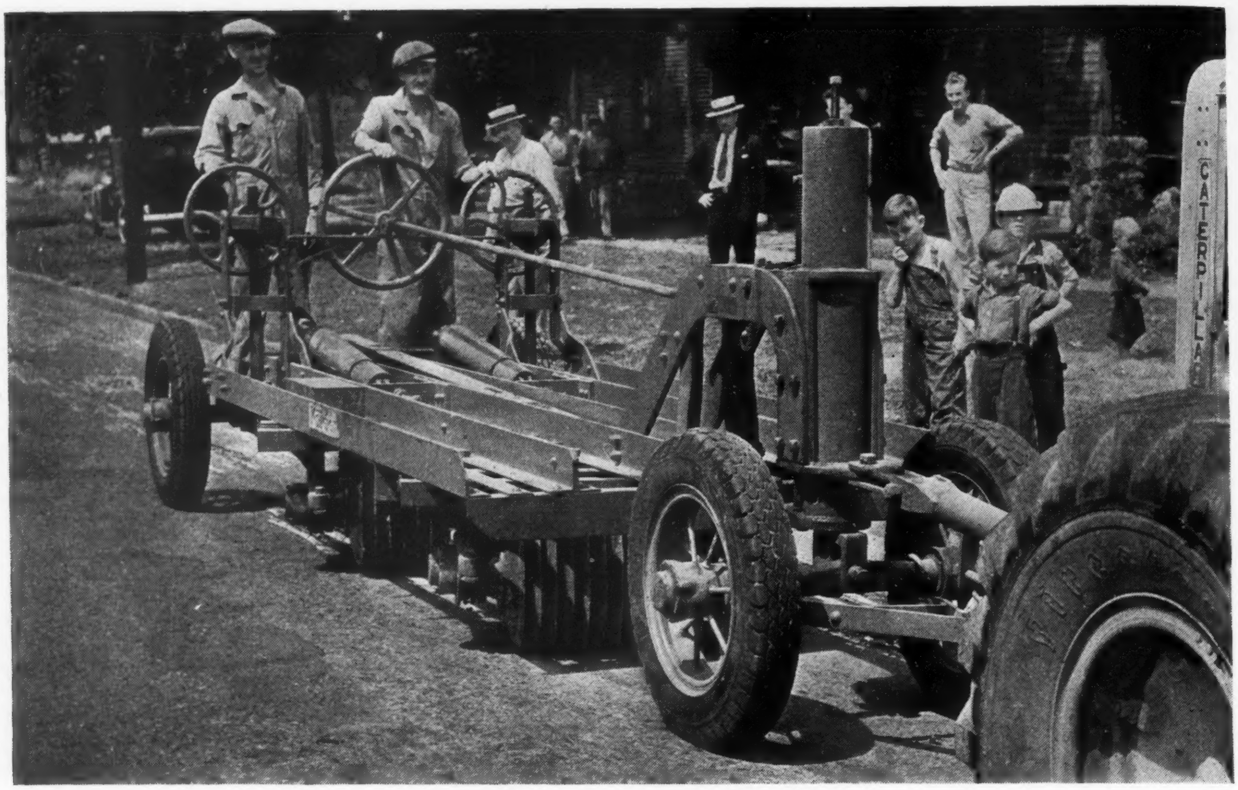
Rough spots in both asphalt and concrete pavements smoothed by cutting down the high spots, filling in the low, and applying a seal coat.

FOR years the good people of Springfield, Missouri, shook their automobiles to pieces driving over rough asphalt and concrete streets, but finally, during the winter of 1939 and 1940, ways and means were sought to correct this condition. Several suggestions were offered, and after trips had been made to various cities which had in the past worked up a reputation for rough pavements, and had, as the fellow said, "done something about it," we concluded that perhaps the smart thing to do was to procure, if possible, a machine that would cut away the high spots on the pavement, and then cover the planed area with an asphaltic coating to seal out water and provide a smooth and durable surface.

A stock machine made by the Killefer Mfg. Corporation was located, with a long-wheel-base that carried four sets of twelve discs 20 inches in diameter. These discs are so arranged that when they strike a high spot on the pavement, they rotate and in so doing cut the surface slightly. In order to produce the required grade and contour of the street and bring the street to the desired uniformity of surface, many trips with the machine were necessary.

Where the surface could not be made smooth without cutting away too much of the old asphalt, or where the planing cut through the surfacing, the low spots were thoroughly cleaned, primed and raked full of an MC-3 mixture which had previously been prepared and properly cured. This mixture was thoroughly rolled with a tandem ten-ton roller, and the street was then ready for its final seal coat. This was applied with a modern asphalt distributor manufactured by the Standard Steel Works and equipped with a positive-control spray bar.

Our average application of seal coat amounted to one-third gallon per square yard of 150 to 200 penetration asphalt, applied at a temperature of 250° F. This was immediately followed with a choking material of Joplin chatt or flint screenings, sized from ½" to ⅛", distributed uniformly at the rate of approximately 25 pounds per square yard. The distribution of these screenings, or chips, was controlled by the use of a "Handy Sandy" spreader manufactured by the Good Roads Machinery Corporation. After the chips had been placed, the entire surface of the pavement was well rolled to embed as many chips as pos-



The machine used for cutting down the high spots.

sible into the asphalt coating. Care was exercised over a period of about three weeks to keep these chips evenly broomed over the streets' surface so that traffic could set them in place.

Our experience has been that no bleeding occurred on this type of work the same year the seal coat was placed, but we found it necessary to have on hand considerable fine flint chips, or Joplin chatts, graded from ⅛" down, excluding dust, to blot out any bleeding that occurred the second summer season.

Applications made as outlined above are very successful in reclaiming badly corduroyed streets and places where the asphalt has cracked due to base failures and allows moisture to enter the base. We have reclaimed 37.4 miles of rough asphalt streets in this manner at a cost of 7.6 cents per square yard.

I might add that the only people who are complaining about this system are the automobile mechanics, who say that since our streets have been given this treatment they have trouble finding a street rough enough to check the squeaks in cars.

Copper Sulphate for Algae Control

Copper sulphate is now being used by several water plants in the Middlewest on the continuous feed basis. The results reported by the various plants feeding the copper sulphate into the mixing basins show no residual copper is obtained in the finished water, secondly, efficient algae control is effected and long filter runs are consequently maintained, and, lastly, the copper sulphate is found to have very beneficial results for controlling certain types of tastes and odors. The average dosage is approximately 6 pounds per 1,000,000 gallons although this will vary with the type of algae present.

Lubrication of Under-Water Bearings

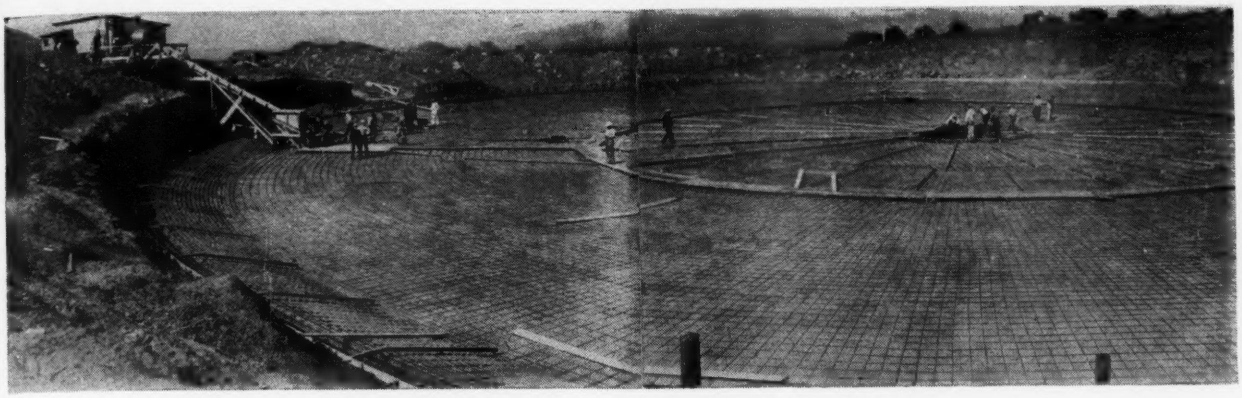
Interesting experiences for six years with the underwater bearings of a flocculator in the water works plant of Bismarck, N. D., are told by the chief operator, William Yegen, in the "Official Bulletin" of the North Dakota State Department of Health. A flocculator was installed in June, 1936, with water-lubricated bearings of fibrous material 1⅛" wide to fit a 3" shaft.

Inspection in 1939 showed excessive wear of both shaft and bearings, the former containing grooves ¼" deep. One shaft was built up with bronze, the others with stainless steel. Also one set of bronze bearings was installed, but the standard fiber bearings were used elsewhere.

In spite of a generally entertained prejudice against using grease in contact with drinking water, Mr. Yegen packed the bearings tight with water pump grease (which does not emulsify in water) and rags were placed around the shafts at the ends of the bearings to keep out abrasive materials.

Inspection in April 1940 found the fiber bearings in good condition; but the bronze bearing had roughened the shaft and was replaced with fiber. A year later all bearings were in excellent condition, as they were still in April 1942.

As a result of this experience, Mr. Yegen said: "The lubrication of the flocculator bearings with water pump grease has been very successful. The use of fiber bearings is more successful than bronze and in my opinion more than any other metallic bearings. The sealing out of the abrasive is just as important as the lubrication itself. During this time we have only replaced the original grease once. We have had no complaints from tastes attributed to the use of such grease. Since using water pump grease I have heard of the use of Crisco for the same purpose with success."



Reinforcement of bottom in place. Concrete plant at the left.

Constructing the La Grande Reservoir

By E. H. FORD
City Manager, La Grande, Oregon

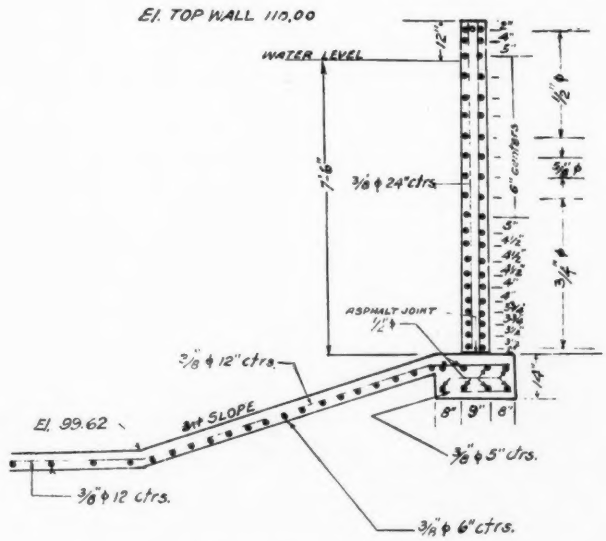
A reinforced concrete reservoir 250 feet in diameter whose circular wall floats on the circumference of a dished bottom that contains no expansion joints.

ON DECEMBER 8, 1941, the city of La Grande, Oregon, put in use a 2½ million gallon reinforced concrete reservoir which is 250 ft. in diameter with a wall 8½ ft. high and 9 inches thick. The engineers' estimate, including a chlorinator and house, was $65,420, and the actual cost was $64,327. The reservoir itself was completed at a cost of $54,000, of which the U. S. Government furnished $33,896 in labor and material and the city's share was $20,104, which was supplied from water revenues.

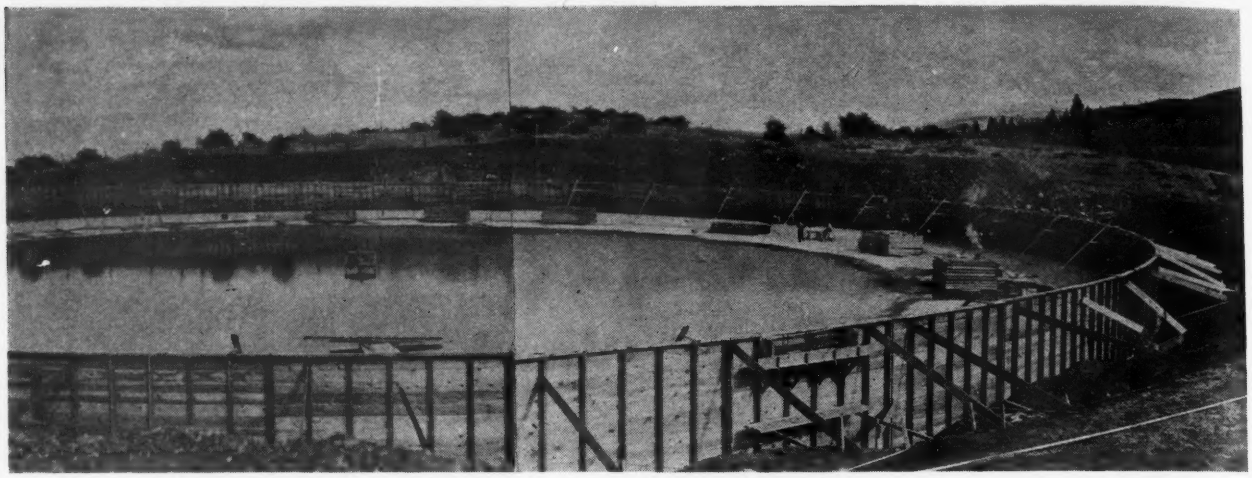
Approximately 75,000 cu. yd. of material was removed with trucks and two Caterpillars with bulldozer attachments. The reservoir was built on the side of a hill about seventy-five feet from the old one and at the same elevation so that the water would flow from the new one to the old, and from there into the distribution system. An 18-inch cast-iron pipe connects the two, the flow of water being controlled by a set of valves. Connection was also made from the new reservoir to the distribution system so that the two reservoirs can be operated independently if necessary. Also the inflow of water can be turned into one or both at the same time.

The main feature of construction was the pouring of the slab or bottom, which is 6 inches thick and 3 feet lower at the center than at the circumference. After the 64,000 lbs. of reinforcing, consisting of ⅜, ½ and ⅝ in. bars, had been tied in place, the mixer was started and pouring commenced, being started at the center and working outward. As soon as the concrete was set enough, it was sprayed with water continually until the end of the shift, when the entire surface that was finished was covered with water. This process continued until the entire slab had been finished. Two shifts of eighteen men each worked sixteen hours a day for fifteen days pouring the slab. When pouring was stopped between shifts, the place where the work stopped was covered with tar paper and when work was resumed the joint was thoroughly cleaned and "Bondsit" (furnished by A. C. Horn & Co.) was applied to make a tight joint. We experienced no trouble in tying on to the concrete between shifts.

The most noticeable thing about this slab is that there is not an expansion joint in it. The outer rim of the slab consisted of an 18 by 25-inch footing, on which the 9-inch wall rested. When the slab had been finished it was allowed to set for five days, when the outer forms were put in place for the walls. These forms were built in the shops and hauled onto the job. The reinforcing steel for the wall was then put in place, a space of 2½ inches being left between the bottom of the upright bars and the footing. There was



Section of wall and floor. Class A concrete used.

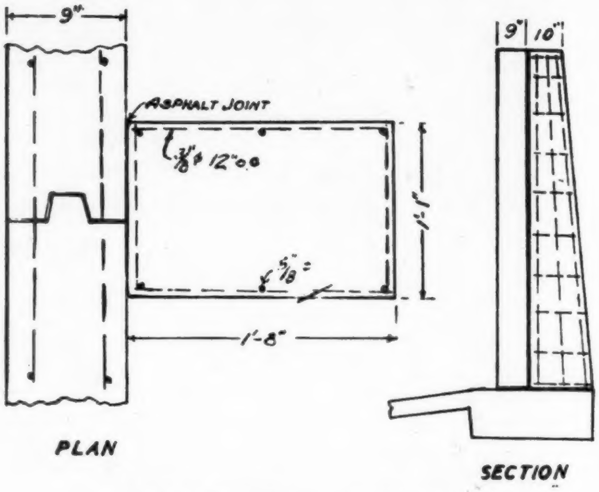


Outside forms for wall in place.

no tie between the wall and the footing; in other words, the wall floats on the footing on a ⅛-inch asphalt joint, which allows the wall to move for expansion or contraction. Then the inside forms were placed and braced by 2x4's which were butted against 2x6's which were bolted to the floor, the bolts for which had been put in when the floor was poured, and were cut off after the forms were removed. At each joint a buttress was built outside the tank, 13 inches wide, 20 inches thick at the bottom and 10 inches at the top.

The walls were poured in four consecutive days, a vertical tongue and groove joint being used between sections. A continuous spray of water was kept on the walls at all times. After two weeks, the forms were removed and a check was made for cracks. We found none except some very small surface cracks which we filled with hot asphalt. After the side forms had been removed the water was drained out of the bottom and it was cleaned and then refilled with water to the walls and allowed to set for ten days. Then the tank was thoroughly cleaned and the water turned in. We have been using the reservoir for seven months and have just finished cleaning it for the first time. We found it in excellent shape, no cracks having developed.

The reservoir was built under the supervision of the writer, with A. H. McLain and Al Hisner as construction foremen. We consider it the finest reservoir in the Northwest.



Details of wall construction joint.

Cities Must Prepare for the Flying Age*

THE general activity of civil aviation has reached such proportions that it must now command special attention if we are to prepare for the emergency and for post-war periods. The industry is a big one and yet it is young. With proper guidance it will influence recovery after the war, and will have an effect on national and international commerce.

It seems logical that further expansion of aviation in peace time will find light planes produced for our air-minded public. In 1939 factories throughout the country produced something over 3,600 small planes; in 1940 the number was doubled; and now, we have over 25,000 private planes registered. It does not appear unreasonable to expect that between 5% and 10% of the number of people now driving automobiles will be flying their own airplanes within a short time after we win this war.

Eventually, we are going to find the need for air parks which will serve as centers for recreational areas and will attract light plane owners for week-ends. Paths to these parks will be the flyways or visually marked routes off the heavy traffic airways, designated strictly for the pleasure flyer.

The war has retarded production of civilian aircraft to some extent, but it has increased the number of pilots who will eventually return to fly in civilian life. It is felt by authorities that we need two million pilots for our fighting forces, and that means it will be necessary to train approximately 2½ million men.

With only 351 transport planes, the airlines flew last year over four million people, carried over 19 million pounds of express, both figures over six times the respective numbers as recorded in 1935. These figures indicate only the beginning.

Freight movement by air will provide the largest rather than the smallest portion of total airline revenues. Transportation of cargo, rather than passengers and mail, is the principal justification for all successful transportation methods, and it will be true also of air transportation.

We plan on a program which will eventually find a properly developed airport for year-round use in every county, at least, and each city of 5,000 or more will definitely need an airport in addition to one which

(Continued on page 24)

*Excerpts from an address before the League of Minnesota Municipalities by Wm. Beadie, of the State Aeronautics Commission.

Operating Sewage Treatment Plants In Westchester County, N. Y.

IN 1936 the Westchester County, New York, Sanitary Sewer Commission was appointed to provide sewerage facilities throughout the county and eliminate the pollution of the Hudson River and Long Island Sound by preventing the discharge into them of the raw sewage from about 370,000 residents of the county. Six years later the commission reported that "pollution of the waters has been eliminated or greatly reduced wherever the sanitary projects of this commission have been placed in operation."

There are now in operation in the county nine systems. The Blind Brook System serves 9,500 population; treats the sewage by means of grit chambers, bar screens, fine screens and chlorine gas; discharges the effluent into Long Island Sound. Sewage from the Bronx Valley, Hutchinson, Upper Bronx and South Yonkers systems serving 231,000 population, is treated at the South Yonkers plant, which comprises grit chambers, mechanically cleaned bar screens, fine screens and chlorine gas. Sewage from the Central Yonkers, Saw Mill Valley and North Yonkers systems, serving 81,600 population, is treated at the North Yonkers plant, which comprises grit chambers with continuous removal mechanism, mechanically cleaned bar screens, fine screens and chlorine gas. The Mamaroneck system serves 50,000 population, the treatment equipment being the same as that at the North Yonkers plant. Of these, the Blind Brook and Mamaroneck plants discharge into Long Island Sound, the other two into the Hudson River. The Blind Brook plant was constructed in 1928, the Mamaroneck and South Yonkers in 1931 and the North Yonkers in 1933.

These plants are housed in well designed buildings, of which that at Mamaroneck (shown herewith) is perhaps the most attractive. This plant treats an average of about nine million gallons a day, increasing to 16 million or more after rains. There are three disc screens (installed by Sanitation Corporation), the screenings from which are burned in a Morse-Boulger incinerator.

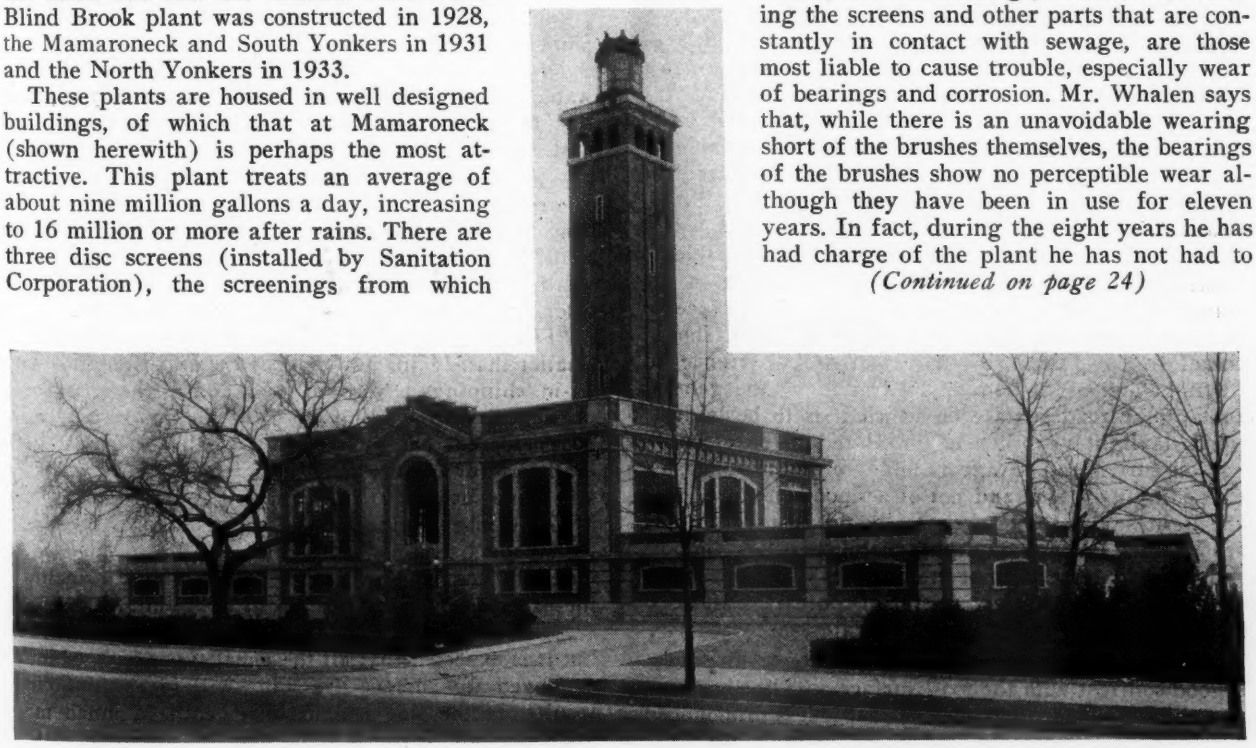
The superintendent of the Mamaroneck plant, Charles J. Whalen, has furnished us with his report for June, which is probably a typical month, from which we obtain the following data.

During the month the air temperature averaged 68.5°, varying from 54° to 82°; the sewage temperature averaged 53°, varying from 50° to 58°; both taken daily at 8 A.M. The amount of sewage treated averaged 9.1 mgd, varying from 6.5 to 16.4 mgd. The screenings averaged 113 cu. ft. per day, with 30 as a minimum. (Both sewage flow and screenings volume increased considerably after rainfalls). This gives an average of 12.4 cu. ft. per million gallons of sewage.

The chlorine applied totaled 19,890 pounds, or at an average rate of 72.7 lb. per million gallons; the dose being designed to keep the residual between 0.5 and 1.0 ppm. Residual readings were taken at 8 A.M., noon, 4 P.M. and 8 P.M. These averaged for the month 0.9 at 8 A.M. and 8 P.M. and 0.8 for the noon and 4 P.M. readings, varying from 0.4 (once only) to 1.0.

The plant operates 24 hours a day, with 6 attendants. The entire equipment operates with practically no "headaches" for the superintendent. Among the accessory equipment are Link-Belt and Stephens-Adamson speed reducers; General Electric motors; Chicago Pneumatic Tool Co. air compressors, and Chapman electrically controlled valves. The operating conditions of the disc screen, with its bearings, brushes for cleaning the screens and other parts that are constantly in contact with sewage, are those most liable to cause trouble, especially wear of bearings and corrosion. Mr. Whalen says that, while there is an unavoidable wearing short of the brushes themselves, the bearings of the brushes show no perceptible wear although they have been in use for eleven years. In fact, during the eight years he has had charge of the plant he has not had to

(Continued on page 24)



Building that houses the Mamaroneck sewage treatment plant.

Night-Time Visibility of Surface-Dressed Traffic Lines

Under blackout conditions an ordinary white painted traffic line is not nearly so visible as one in which light-colored stone chips have been embedded.

THE Road Research Laboratory in Great Britain, with the cooperation of the Ministry of War Transport, has been studying the production of white traffic lines by use of white or light-colored stone chips held to the road surface by tar or asphalt. (This method, as developed by the Indiana Highway Commission, was described in the February, 1941, issue of PUBLIC WORKS; and a modification using glass beads in April of that year.) Although this investigation is being continued, the Laboratory has published certain findings that seem warranted by results already obtained.

They find that a "surface-dressed" line (one produced as described above) viewed from a car in daylight may not be as visible as a new or nearly new painted line, though with the best aggregate on a black surface the difference is not usually very great. But under black-out conditions the surface-dressed line is decidedly more visible, provided the stones have not become submerged in the bitumen, "because it has a rough-textured surface which reflects back an appreciable amount of the light of the headlamp to the driver. A new paint line on a rough-textured road surface has the same characteristics; but on a smooth road, particularly when the surface is wet, little of the light is reflected back toward the driver and the visibility of the line is poor. As the paint line wears, this factor becomes accentuated. The advantage of the rough-textured line is particularly noticeable at a distance of 50 ft. or so ahead of the car, where the illumination has dropped in intensity and is at almost grazing incidence to the road.

"Because of this effect of texture, it is possible to obtain good night-time visibility with stones that are considerably off white or not white at all. Choice of the type of stone for surface-dressed lines should therefore be guided by the relative importance of daylight and night-time visibility and by the general tone of the road surface on which it is to be laid. If good daylight visibility is considered to be essential (as on curves and bridge ramps), or if the road surface is light in tone and not of a smooth texture, only the lightest type of aggregate should be used for the traffic lines. Where daylight visibility is less important (as for intermittent traffic lines) and on black road surfaces, a sufficient degree of contrast is afforded by off-white or light brown aggregates.

"For continuous lines and aggregates which give a good contrast with the road surface a 6″ line has been found to be sufficient. If the contrast is less pronounced a 9″ line is preferable, but there is probably little advantage in increasing the width beyond this figure.

"The chippings, besides being light in color, should have adequate strength and should not easily discolor by surface absorption or weathering. From the latter point of view it appears that the surface of the stones should be either hard or smooth-textured, as in a water-worn gravel, or should show a coarsely crystalline fracture with relatively large smooth facets. The best results have been obtained with white quartzite, but satisfactory lines can also be laid with light-colored gravels. Limestones have been tried, but showed considerable deterioriation in color through absorption of oil and dust, and to a certain extent through weathering. Calcites, although satisfactorily light in color, are too weak to be generally satisfactory.

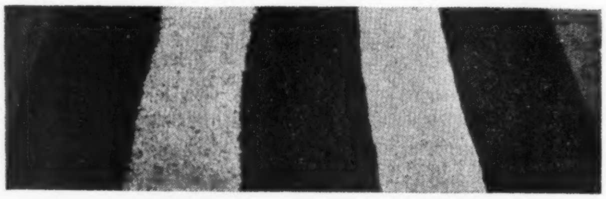
"For good visibility the size of stone should not be smaller than ¼ in. For most of the experimental work ⅜-in. chippings have been used, and as there has been no difficulty in holding these to the road surface, it is considered that this size is probably the most generally useful. Where the road surface is soft, a larger size stone such as ½ in., or, in exceptional cases, even a ¾-in., might be found more satisfactory.

"About 4 tons of ⅜-in. chippings are needed for a mile of 6-in. continuous line; this quantity includes the excess which is swept up after laying.

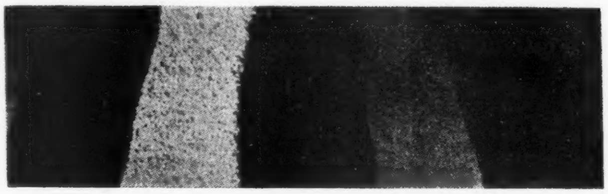
"The trials so far made have been with tar binder, but it is expected that all the usual types of hot binder employed for surface dressings will give satisfactory results. If the line is laid by machine a much more viscous binder can be used than for normal surface dressing work, since the chippings are applied within

(Continued on page 24)

A—By vertical lighting (daylight).

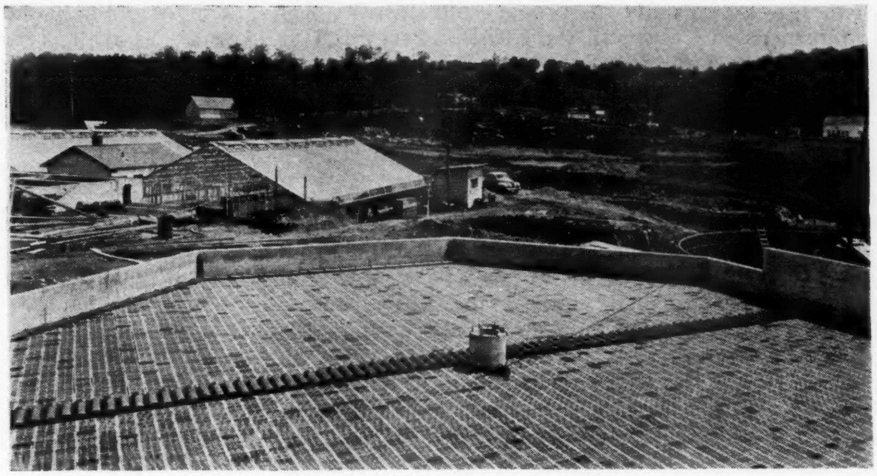


Surface-dressed line. **Painted line.**



B—By light from car headlamp (night-time).

Comparison of painted and surface-treated lines.



View of part of the Liberty, N. Y., Sewage Treatment Plant, with Biofilters under construction in the foreground. The two glass-covered sludge beds are seen in the left background.

Operating Results of the Liberty, N. Y. Biofilter Plant for the Summer of 1942

With an approximate average load on the filter of 2.3 pounds of B.O.D. per cubic yard, the B.O.D. of the effluent never exceeded 10 ppm., and the suspended solids remained under 9 ppm.

THE Liberty, N. Y., sewage treatment plant has been described previously in this journal (July and October, 1940 issues). Operating results for 1941 were given in the issue of December, 1941. Essentially, the plant consists of a mechanically cleaned Link-Belt screen; primary settling tanks equipped with Link-Belt "Straightline" collectors; 2 biofilters 80 ft. in diameter and 3 ft. deep, equipped with Dorr distributors; Fairbanks-Morse recirculating pumps of 1400 and 2100 gpm. capacity; a final clarifier, with Dorr sludge collectors; a magnetite filter; and chlorinator. Accessory equipment includes a Dorr digester, a Conkey sludge filter and covered sludge drying beds.

The plant is designed to treat 1 mgd. with an average B.O.D. of 425 ppm. On the basis of design, the primary settling period is 70 minutes, and final settling 60 minutes. By taking off sewage for recirculation near the central feed of the final clarifier, the detention period in this clarifier is actually approximately 3 hours. The magnetite filter is designed to operate at 1½ gallons per sq. ft. per hour, and a somewhat finer filtering medium than normal is used.

Figures given below are based on hourly composites taken from 8 A.M. to 2 P.M. for raw sewage and 9 A.M. to 3 P.M. for effluent. Therefore the figures will be higher than would be shown by 24-hr. composites. Tests made by the New York State Department of Health in July and August, 1941, indicated roughly that the 24-hour composites of the raw sewage were about 70% as strong as the 6-hr. daytime composites. The plant is operated by one man working on an 8-hr. shift, with such additional labor help as may be needed. It is unattended for 16 hours per day. This one-man, 8-hr. operation is the reason why 6-hr. composites are taken and reported.

In the table herewith are shown in Column 1, the date; in Column 2, the B.O.D. of the raw sewage before the primary filter effluent is returned to the primary tank inlet; in Column 3, the B.O.D. of the sewage actually flowing into the primary tank, consisting

B. O. D. RESULTS AT THE LIBERTY PLANT

(1) 1942	*(2)* Raw Sewage	*(3)* Primary Influent	*(4)* Primary Effluent	*(5)* Primary Filter Effluent	*(6)* Secondary Filter Influent	*(7)* Secondary Filter Effluent	*(8)* Clarifier Effluent	*(9)* Final Effluent	*(10)* D.O. Effluent	*(11)* Flow Mgd.	*(12)* S.S. Raw	*(13)* S.S. Final
June 3...	280	260	120	90	40	25	18	7.	8.0	0.68	192	6
" 10...	360	280	113	90	40	27	25	10.	6.6	0.62	432	9
" 13...	340	300	107	47	26	21	18	8.	—	0.56	172	7
" 22...	280	150	120	54	34	35	17	6.	7.4	0.81	196	8
" 26...	310	210	140	50	50	23	18	8.	7.4	0.68	256	6
July 2...	330	210	140	—	66	23	12	8.	6.4	0.62	216	7
" 6...	300	220	140	92	56	30	24	9.	6.0	0.81	204	4
" 9...	250	360	146	—	60	33	24	8.	6.0	0.	180	3
" 15...	340	230	180	106	64	40	25	8.	5.8	0.75	184	5
" 24...	400	320	220	95	65	40	22	7.	5.2	0.75	236	7
Aug. 5...	420	280	170	120	60	38	26	7.	6.0	.95	220	4
" 8...	420	270	210	110	60	40	23	6.	—	.75	316	3
" 18...	280	240	160	83	58	36	23	6.	6.2	1.10	172	6
" 21...	320	240	170	75	60	33	19	7.	5.8	.95	172	6
" 24...	400	320	170	80	60	32	26	9.	6.0	.95	232	5
" 28...	360	270	160	100	47	35	25	7.	5.8	.88	244	6

of the raw sewage and the primary filter effluent that is returned; in Column 4, the B.O.D. of the primary tank effluent; in Column 5, the B.O.D. of the primary filter effluent; in Column 6, the B.O.D. of the secondary filter influent; Column 7, the B.O.D. of the secondary filter effluent; Column 8, the B.O.D. of the final clarifier effluent; Column 9, the B.O.D. of the effluent after passage through the magnetite filter; Column 10, the D.O. of the final effluent; and Column 11, the flow in million gallons per day. Column 12 shows the suspended solids in the raw sewage and Column 13 the suspended solids in the final effluent.

The results in Column 2 ordinarily exclude the supernatant return. For instance, samples taken on June 3, 10 and 13, which included supernatant overflow, showed, for the raw sewage before mixing with the return from the primary filter, B.O.D. of 520, 520 and 470 respectively.

Liberty is a summer resort and the principal load comes during the three summer months. The plant is so designed that it may be operated as a straight trickling filter during the low-load periods. Ordinarily it is operated as a biofilter from April to or through October, depending on weather and stream flow. In the spring about four or five weeks are required after recirculation and high-rate operation has begun, to obtain the results shown in the table herewith. As a straight trickling filter the loading, under average winter flow and sewage strength, amounts to about 1.25 pounds of B.O.D. per cubic yard of filter media based on 6-hr. composites of daytime flow. As a biofilter, the approximate average loading on the same basis during August, 1942, was 2.3 pounds per cubic yard.

It is interesting to note the uniformity of results obtained during the past summer. The B.O.D. of the final effluent did not exceed 10 ppm. and the suspended solids did not exceed 9 ppm. Primarily this was due to the skilled and careful operation of the plant by the operator, Harry Eichenauer. John Lawrence is Superintendent of Public Works and has general charge of sewage collection and disposal.

Cities Must Prepare for the Flying Age

(Continued from page 20)

may be built for the rest of the county. Fortunately an airport built now for military purposes will serve adequately in peace time. In other words, the city spending money for an airport now will have its investment secured in post-war periods.

The general requirements for an airport include selection of a site that can be developed into an area one mile square, on ground that can be adequately drained, and in a location free from obstructions. The first stage of development should be on an area not less than 160 acres in order that you have landing strips at least 2,500 feet in length. Your master plan will be on the basis of the ultimate development of one square mile, but you will build as needed, and in this way each step will be a part of your final design—extensions can be made as needed without interfering with the building area.

A thorough study must be made of the surrounding territory to determine the zoning requirements. Zoning has become one of the important factors of successful airport operation, and it is also one of the most complex and troublesome problems. There are differences of opinion concerning the constitutionality of zoning laws: one, that zoning is confiscatory when no payment is made, based on "due process of law"; another that zoning is important from a public benefit standpoint. I concur in the latter, though I am not a lawyer, and cite as basis of reasoning the opinion of Dean Ladd, University of Iowa, that the doctrine of police power is a protection where the harm is insignificant and the benefit is great to the many. Aviation has become so important to the nation that it is justifiable to give it every protection, and ownership of property adjoining an airport should be sacrificed for the common good.

The operation of an airport is no different from any other business, assuming that a qualified person is in charge, and the entire venture is treated from the start in the same manner as a light plant or other revenue-producing projects. The return from an airport will not retire bonds in the first years of operation but if properly managed enough money will be received to pay operating costs and interest on the investment; as the volume of business increases, more reserve will be available either to add improvements or to pay off the original investment. Even the possibility of not being able to pay off the original indebtedness from receipts from the aviation industry is not serious. Your parks, swimming pools, streets, etc., are not profit-making industries but the entire public benefits and should, therefore, pay a proportionate share of airport construction.

There are several Federal agencies which may be in a position to assist in the building of an airport but, at present, none will buy land or draw plans. Therefore, your local authorities must select a site, control it by purchase or option, and then have it surveyed in preparation for an airport design. It is at this point that an estimate of cost can be analyzed.

It has been my experience that the city with the necessary property and plans is in an extremely favorable position to receive outside assistance. It is simply a case of helping ourselves during these times and not waiting for some mysterious Washington authority to appear in each community with a complete airport, wrapped and ready for delivery. You will take note that your efforts will contribute to our preparedness and still leave you with a development required for peace time.

Operating Sewage Treatment Plants in Westchester County

(Continued from page 21)

renew any of the bearings in the plant. This he attributes to his use of a lubricant—"Lubriplate"—which seems to be especially suitable to such conditions, not only as a lubricant but also because it protects the surfaces from corrosion. This is applied to all the equipment about once a year with a hydraulic gun. It is used also at the North Yonkers plant, where there are 4 disc screens, and at the South Yonkers, where there are 6.

Night Time Visibility of Surface-Dressed Traffic Lines

(Continued from page 22)

a fraction of a second of the laying of the binder. No difficulty has been found in spraying tar of viscosity 400-500 seconds at 30 deg. C, in May; in particularly hot weather it might be an advantage to use even higher viscosities. In order to reduce early displacement by traffic and to minimize risk of "fatting up" it is desirable to use the highest viscosity possible consistent with the technique of application."

The Operation of Sewage Treatment Plants

(Continued from page 13)

sewage work, but quite frequently in water purification, is grains per gallon, or *gpg.* 1 grain per gallon equals about 143 pounds per million gallons, or 143 $\div$ 8.33 = 17.1 parts per million.

The main units of the plant, such as the pump and blower station, the primary and final settling tanks, and the aeration tanks, are designed by the engineer for maximum efficiency within a certain flow range and sewage quality. This requires close control and coordination of operation of these units; hence accurate measurement of flow of raw sewage, settled sewage, air, mixed liquor, sludge, and final effluent. On the chemical side, dosages must be closely and preferably automatically proportioned to the continuously varying amounts of sewage and sludge. Accurate meters, therefore, preferably of the indicating, chart recording, and integrating type, are essential to guide the plant operator in his supervision and to obtain data for progressive improvement. The accompanying diagrammatic plan of an activated sludge plant shows an ideal arrangement of meters for such an installation.

4. *Hydraulic Terms and Relations*—The flow of sewage is usually stated as so many gallons per day, abbreviated *gpd.;* or occasionally as gallons per minute, *gpm.* When very large flows are concerned the term cubic feet per second may be used, abbreviated *cfs.;* or millions of gallons per day, *mgd.*

5. *Relations Between Terms*—A flow of 1 gallon per minute equals 60 gallons an hour or 1,440 *gpd.;* 100 gpm equals 144,000 gpd.; 700 gpm. equals very nearly 1,000,000 gpd. There are 7.48 gallons in 1 cubic foot; therefore 1 cfs. equals 7.48 gallons per second, or nearly 450 gpm., or 646,200 gpd., or 0.646 mgd.

6. *Temperature*—There are two common methods of measuring temperatures, Fahrenheit, abbreviated F., and Centigrade, abbreviated C. The former is most commonly used in the United States for everyday work; the latter is used almost exclusively in scientific work. The operator should be able to use each in terms of the other. In the F. scale, freezing of water is at 32°, and boiling is at 212°, a difference of 180° between freezing and boiling. In the C. scale, freezing is at 0° and boiling at 100°, a difference of 100° between freezing and boiling. Two simple formulas may be used:

$$C = \frac{(F\text{-}32)5}{9} \text{ and } F = \frac{9C}{5} + 32$$

To change an F. reading to a C. reading, subtract 32 from the F. reading, divide the remainder by 9 and multiply by 5. Thus to find what 104° F. is on the C. scale, subtract 32, leaving 72; divide this by 9, which gives 8; multiply this by 5, which gives the answer, 40° C. To change a C. reading to F., divide by 5, multiply by 9 and add 32. Thus, to find the F. value of 30°C.: Divide by 5, which gives 6; multiply by 9, which gives 54; add 32, which gives 86° F., the answer. Fig. 1 shows a scale in which equivalent F. and C. temperatures may be read directly.

III.—Sewage Characteristics and Composition

1. *General*—Sewage as it flows in the sewers and before it arrives at the treatment plant is called *raw sewage,* or, in treatment terms, influent. After passage through the plant it is *treated sewage* or *effluent.*. A part of a report on the analysis of a raw sewage may read something like this:

Total Solids	980 ppm.
Volatile Solids	595 ppm.
Non-Volatile Solids	385 ppm.
Suspended Solids	270 ppm.
B.O.D. (5-day)	226 ppm.
pH.	7.0

What do these mean in terms of what the operator ought to know in order to run his plant efficiently?

2. *Total Solids*—This means just what it says; the total solids in the sewage sample are 980 parts per million, that is, in a million pounds of sewage there are 980 pounds of dry solids. These solids may be classified further and should be, in order to know what the sewage contains, for some of them will be grit and sand, and others will be feces, bits of vegetables, etc.

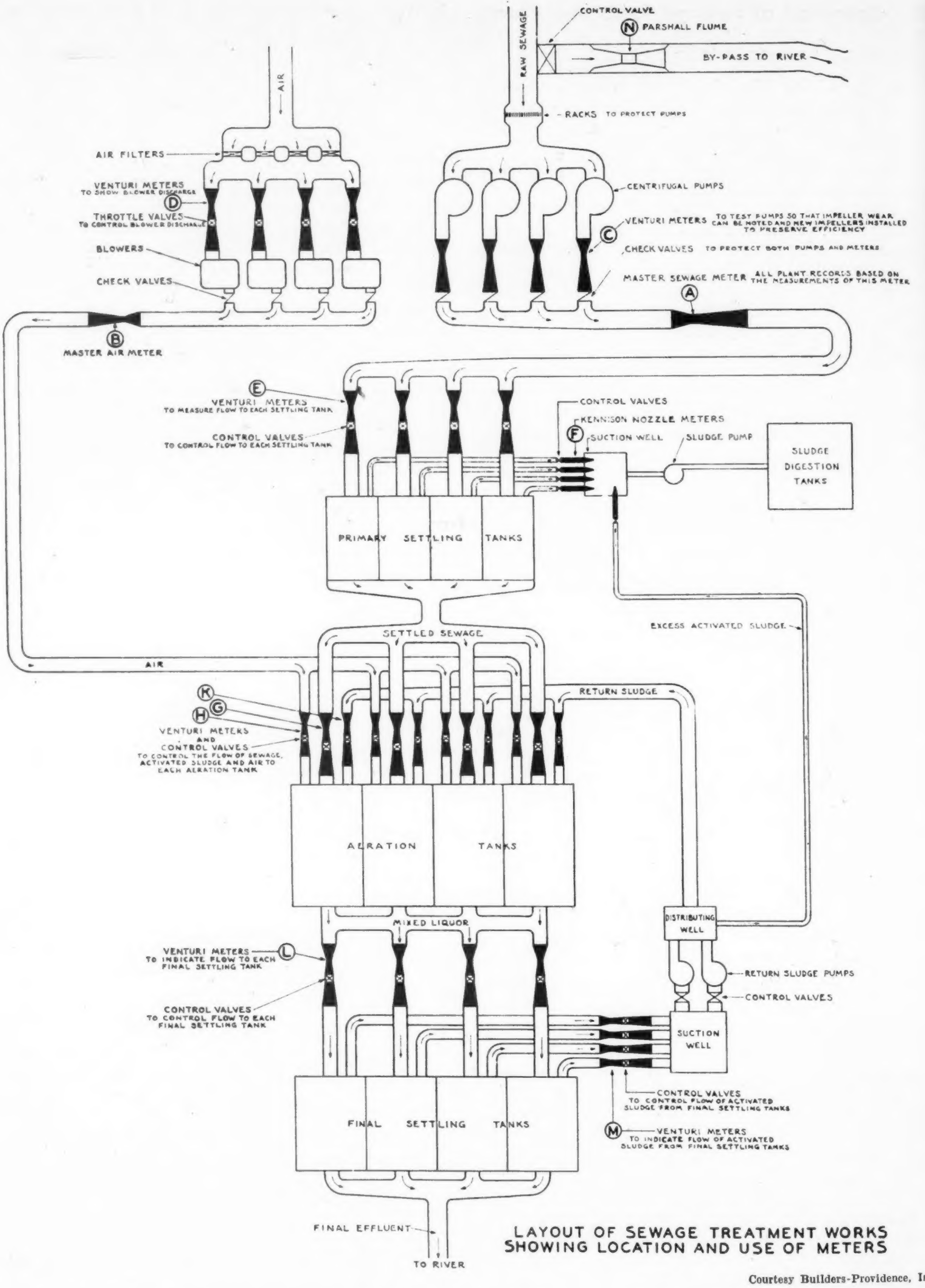
The grit and sand (also carbonates, sulphates, etc.) are called fixed non-volatile, or inorganic solids. These will not decompose, though sometimes difficult to handle. The organic material mixed with them when they are improperly washed may cause odors. The feces, vegetable particles and other elements of a similar nature are the organic or volatile solids and treatment of them is what gives the operator his job, and also most of his troubles.

This particular analysis was picked from a real plant. It showed that the sewage contained 980 ppm. total solids, of which 385 ppm. were inorganic and 595 ppm. were organic. Considering the latter, this means that in 100 gallons of sewage there are only about 7½ ounces of organic matter—a very small amount, but sufficient nevertheless to cause the sewage to decompose with odor.

3. *Suspended and Dissolved Solids*—Some of the solids in sewage are dissolved as sugar is dissolved in coffee; these represent about 60% or more of the total; others are colloidal in nature and are too finely divided to be filtered out; still others are suspended in the form of particles of various sizes, and these suspended solids are both organic and inorganic. If the sewage is held quiescent in a tank or basin, some of the suspended solids will settle to the bottom. Usually not over half the suspended solids will be removed by such settling or sedimentation. In the sample we are considering, the suspended solids amounted to 270 ppm., and about 50% will ordinarily be removed by sedimentation. Therefore an analysis of the effluent from the primary sedimentation tank should show about 135 ppm. of suspended solids.

Not all of the suspended solids will settle out; those that will settle are called settleable solids. A test for settleable solids consists of allowing the sewage to settle for 1 or 2 hours in special glass jars (Fig. 2), called Imhoff cones. The results obtained by this test are not the same as is obtained in actual plant operation; but the test gives an idea of the amount of material that may be removed by settling for 2 hours or so.

It is not practical to remove all the solids from sewage by treatment process, nor is it necessary to do so. In most sewage treatment plants, the total solids are not greatly reduced—perhaps only 25% to 40%—but the remaining organic solids are changed over to remove so far as is possible their troublemaking characteristics. Thus the sewage treatment plant is designed to: (1) Remove suspended solids, both organic and inorganic, so far as possible; (2) convert organic matter into stable forms.

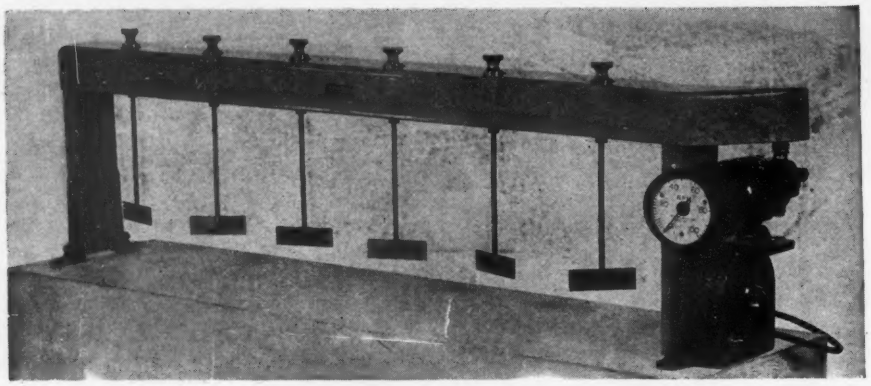


LAYOUT OF SEWAGE TREATMENT WORKS SHOWING LOCATION AND USE OF METERS

Courtesy Builders-Providence, Inc.

4. *B. O.D.*—These three letters are a simple way of writing the rather awesome term "Biochemical Oxygen Demand." The B.O.D. of a sewage is the amount of oxygen necessary to stabilize the unstable and decomposable organic matter present.

The B.O.D. of the sample considered at the beginning of this section was 226. This means that 226 ppm. of oxygen are necessary for satisfying the demand of the organic matter present during a stated period (5 days in this case). Remembering that 1 ppm. = 8.33 pounds per million gallons, 226 x 8.33 or about 1,883 pounds of oxygen must be supplied to each million gallons of the sewage by means of the treatment devices to satisfy the B.O.D. of 226.



Phipps & Bird laboratory stirrer.

In fact it will take more than this—about one-third more. To accomplish complete stabilization of the organic matter, several months are required. This is too long a period over which to run tests; and results three or four months after the sample is taken are not of much value in guiding operation. Therefore, in testing work, the results at the end of 5 days are usually taken. The B.O.D. of 226 is the standard 5-day B.O.D. result. Experience has shown that the 5-day B.O.D. is about 68% of the final B.O.D. requirement. The total biochemical oxygen demand therefore is about 2,770 pounds per million gallons of sewage. This oxygen is supplied by such treatment equipment as trickling filters and aeration tanks, and also by the dissolved oxygen that is present in the stream into which the sewage is discharged.

Average streams may contain, depending on temperature and other factors, 8 to 10 ppm. of dissolved oxygen. Neglecting other factors and assuming it is necessary not to exhaust all of the dissolved oxygen (D.O.) from the stream, 5 ppm. of the D.O. may be considered as available to meet the oxygen demands of the sewage.

In the same sewage which has been discussed, the 5-day B.O.D. of the settling tank effluent was 148; and of the trickling filters 43. The effect on the stream of the discharge of the raw sewage (B.O.D. 226), of the settling tank effluent (B.O.D. 148) and trickling filter effluent (43) can be computed. It may be easier to compute how much water, with 5 ppm. of dissolved oxygen would be necessary to provide the necessary oxygen to supply the requirements, as shown by the 5-day tests.

With the raw sewage, there would be required $226 \div 5$, or about 45 times as much water as sewage; for the tank effluent, $148 \div 5$, or nearly 30 times as much water as sewage; and for the trickling filter effluent, $43 \div 5$, or about 9 times as much water as sewage.

5. *pH*—This is a measure of the intensity of the acidity or alkalinity of the sewage, and is important in several ways. In these treatment plants where sedimentation only, and not chemical coagulation nor activated sludge treatment is used, the pH is mainly of value in guiding the operator in the treatment of sludge. Best digestion is usually obtained when the sludge is slightly alkaline; but some plants report good digestion with pH of 6.8 or slightly lower.

When chemical coagulation is employed, a knowledge of the pH value of the sewage is necessary to get most satisfactory results with the chemicals employed; and in activated sludge treatment plants in order to secure satisfactory results in operation.

A pH value lower than 7.0 shows acidity; and greater than 7.0 alkalinity. The lower the value, below 7.0, the greater or more intense the acidity; and the higher the value above 7.0, the more intense the alkalinity. (More data regarding pH will be found in the next section.)

6. *Other Tests* — There are many other tests of greater or less value to the operator. Among those of value are the putrescibility or methylene blue test, used principally in the smaller plants; and the residual chlorine test. These along with the tests already mentioned in this chapter will be described (with one or two exceptions) in succeeding paragraphs.

In addition, there is the D.O., or dissolved oxygen test which shows the dissolved oxygen content of the sewage or of the water into which it is discharged. In the sewage sample we have been using in this article, the D.O. of the raw sewage was 1.2 ppm. and of the trickling filter effluent 7.4 ppm. See Par. 4, this section for the effect of D.O. on streams receiving the sewage. Other tests sometimes used include those for: (a) free ammonia, which is a measure of the decomposition that has already taken place; (b) the organic nitrogen; (c) the total nitrogen; (d) the nitrogen as nitrites and as nitrates; (e) turbidity; and (f) the oxygen consumed. These tests usually are not as important to the operator as those previously mentioned.

There is evidence that the alkalinity of sewage may affect coagulation in chemical treatment; and the amount of free CO_2 (and also of nitrates) may affect algae growths in the stream receiving the plant effluent. Alkalinity of the digester supernatant also may provide an excellent guide to digester operation.

IV.—Tests and How to Make Them

1. *Laboratory Equipment*—A laboratory and laboratory equipment are required for every plant. It is not necessary that the laboratory be large, nor the equipment costly. What is needed depends upon the tests that are to be performed, and these in turn depend upon local conditions. A laboratory layout for a small plant and a list of the equipment needed to make the various tests can be obtained from your State Board of Health by addressing the State Sanitary Engineer, or will be furnished by the Editor of this magazine without charge. *Standard Methods of Water and Sewage Analyses* can be obtained from the American Public Health Association. Orders will be forwarded to the publishers of this book by the Editor of this magazine. Other books of value for laboratory use and guidance are: *Analysis of Water and Sewage*, by Theroux, Eldridge and Mallmann; and *Operation of Sewage Treatment Plants* by Hardenbergh. Both of these texts outline in a simplified form the procedures for making the tests and will be found of special use to those who have not completed a formal course in laboratory procedures.

EQUIPMENT FOR SEWAGE PLANT LABORATORIES
Recommended by the Committee on Laboratory Equipment of New Jersey Sewage Works Ass'n

List No. 1—For testing relative stability, settleable solids and pH value.

Apparatus: 1 incubator, electric with thermostatic control. 3 Imhoff cones, 1000 cc capacity. 1 pH apparatus, colorimetric, double comparator with dyes and color standards to cover the ranges of phenol red, brom-thymol blue, and chlor-phenol red. Orthotolidine testing set for chlorine. Bottles—3 glass-stoppered, 5-pint; 12 wide mouth, 250 cc, with corks; 24 narrow mouth, 250 cc, ground glass stoppers; 1 narrow mouth, 1,000 cc, ground glass stopper; 1 wash bottle, 1,000 cc. 2 pipettes, Mohr, 1 cc calibrated in 1/10 cc. 1 ring stand, base 6½" x 9",

rod 36" x 0.7" and one 3" ring with screw clamp. 1 glass funnel, short stem, dia. 5".

Chemicals: 10 gms. methylene blue. ¼ lb. coarse glass wool. 5 gal. distilled water.

Total cost about $50 without incubator, $125 with incubator.

List No. 2—For determining B.O.D. (dissolved oxygen), suspended solids, settleable solids, total solids, ash, pH value (residual chlorine).

Apparatus: 1 incubator as above. 4 1,000 cc Imhoff cones. 1 pH apparatus as above. 1 Orthotolidine testing set as above. 1 analytical balance, cap. 100 gm., sensitivity, 0.1 mg., with set of balance weights 1 mg. to 50 grams. 1 drying oven, electric with thermostatic control. 12 crucibles, Coors porcelain, cap. 15 cc, ht. 27 mm. 12 Gooch crucibles, cap. 25 cc, ht. 40 mm. 2 Gooch crucible holders to fit 2" funnel. 1 pair crucible tongs, nickel, 8" long. 2 suction flasks, pyrex, heavy wall, cap. 500 cc. 2 funnels, glass, short stem, 2" diam., and 2 of same 5" diam. 1 desiccator with plate, 6" inside diam. 10 cylinders, graduated, 2 each of capacities of 50 cc, 100 cc, 250 cc, 500 cc and 1,000 cc. 6 beakers, pyrex, low form with lip, cap. 400 cc. 2 pyrex Erlenmeyer flasks, cap, 500 cc, with rubber stoppers. 1 500 cc volumetric flask. 2 50 cc burettes with straight glass stopcock, and a stand to hold 2 burettes. 10 pipettes, 2 each of capacities of 2 cc, 5 cc, 10 cc, 1 cc calibrated in 0.1 cc and 10 cc calibrated in 0.1 cc. 1 water suction pump 3¾" x ⅛". 1 ring stand base 6½" x 9", rod 36" x 7/16", without rings. 2 2½" watch glasses. 6 porcelain evaporating dishes 85 mm diameter. 2 Bunsen burners (if gas is available. If not, gasoline torches may be used). 2 silica triangles, 2" on each side, on michrome wire. Bottles: 6 acid, glass stoppered, 5 pint; 2 narrow mouth, ground glass, flat stoppers, 1,000 cc; 6 of same of 500 cc, 36 of same of 250 cc; 24 wide mouth, with corks, 250 cc. 1 pyrex washing bottle, 1,000 cc. 6 ft. of suction hose for vacuum pump connections. 6 ft. of rubber tubing, 5 mm inside diam., heavy wall. 12 ft. of glass tubing, 7 mm outside diam. 3 ft. of 6 mm glass rod. 2 rubber stoppers, one-hole, to fit suction flasks. 1 spatula, 3" blade length. 1 maximum and minimum thermometer 8" long.

Chemicals: ¼ lb. asbestos, medium fibre, washed and ignited. 2 lb. potassium hydroxide sticks. 8 oz. potassium iodide. 1 oz. potassium bichromate. 1 oz. potassium permanganate. 4 oz. potassium oxalate. 8 oz. manganous sulfate. 9 lb. sulfuric acid. 4 oz. sodium thiosulfate. All the above c.p. Also 4 oz. soluble starch. ¼ lb. glass wool, coarse. 5 gal. distilled water. 1 lb. calcium chloride in lumps for desiccator. 1 lb. potassium bichromate for making cleaning solution.

Total cost about $300.

List No. 3—For activated sludge plants or those using some form of secondary treatment. Additional to the items given in list No. 2.

Apparatus: 1 analytical balance, cap. 100 gm., sensitivity 0.1 mg., with set of weight 1 mg. to 50 mg. including riders. 24 crucibles, Coors porcelain, 15 cc. cap., 17 mm. ht. 24 Gooch crucibles, 25 cc cap., 40 mm. ht. 4 funnels, glass, short stem, 2" diam. 6 Imhoff cones, 1,000 cc capacity. 2 50 cc indicator dropping bottles. 12 pyrex beakers, low form with lip. 250 cc cap. 3 pyrex beakers, low form with lip, 1,000 cc cap. 2 1-liter pyrex, flat-bottom flasks with rubber stoppers. 1 250 cc volumetric flask with rubber stopper. 1 1,000 cc volumetric flask. Pipettes, 3 2 cc, 3 5 cc and 3 10 cc. 6 Mohr pipettes, 1 cc cap. calibrated in 0.1 cc. 2 Buchner funnels, 8 cm inside diam., and 3 packs of coarse filter paper to fit. 2 ring stands, base 5¼" x 9", rod 24" x ½". 4 2½" watch crystals. 12 50 cc Nessler tubes, long form, and stand for same. 8 1,000 cc narrow mouth bottles, ground glass flat stoppers. 48 250 cc wide mouth bottles with corks. 12 pyrex test tubes with lips. 25 mm dia., 200 mm long. with one-hole rubber stoppers to fit, and stand for these. 3 ft. of suction hose. 4 rubber stoppers to fit suction flasks. 1 set of cork borers, 3/16" to 9/16". 2 maximum and minimum thermometers. 1 9" x 12" electric hot plate.

Chemicals: 4 oz. mercuric chloride. 4 oz. ammonium chloride. 1 oz. alphanaphthylamine crystals. 1 oz. sulfanilic acid. 1 oz. silver nitrite. 4 oz. sodium chloride. All the above c.p. Also 1 lb. acetic acid, glacial, U.S.P. 4 oz. aluminum foil. 10 gm. methylene blue.

Additional chemicals required to run tests for acidity, alkalinity and chlorides; 1 lb. hydrochloric acid. 1 oz. potassium chromate. 1 oz. silver nitrate. All the above c.p. Also 1 oz. methyl orange. 1 oz. phenolphthalein U.S.P. 500 cc standardized N/10 sulfuric acid.

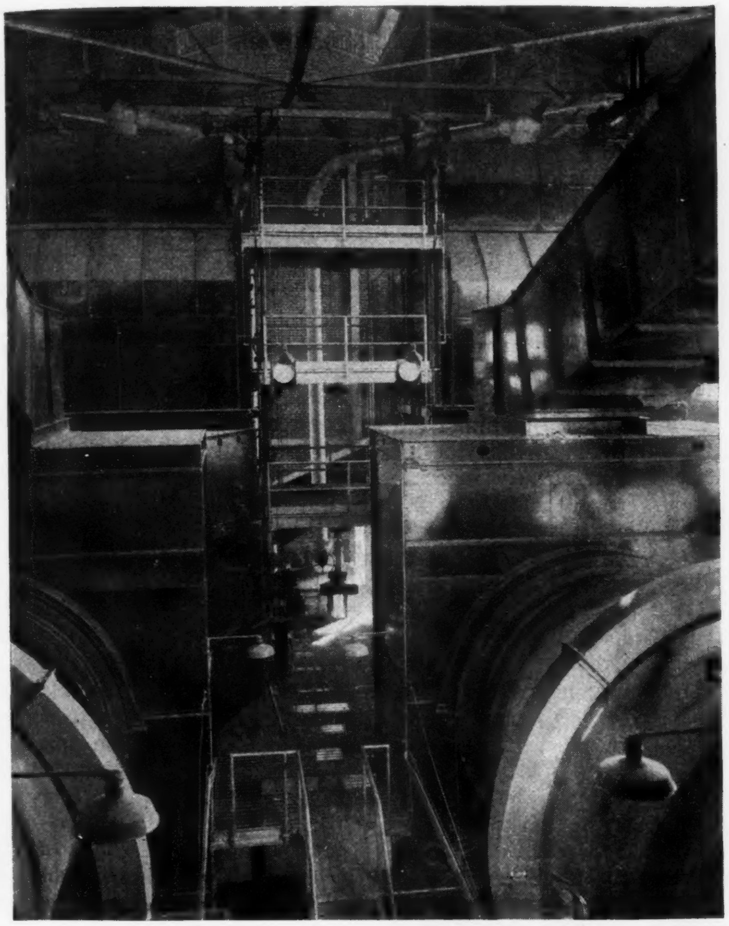
Total cost about $400.

2. *Tests of Value*—Some laboratory control of a sewage treament plant is necessary. Certain tests, few in number and not difficult to make, even for the man unaccustomed to this type of work, are of much value in indicating results of operation and also in controlling the operation of a plant. These tests are those for:

a. Total solids.
b. Settleable solids.
c. pH (hydrogen ion concentration).
d. Alkalinity.
e. Residual chlorine.
f. Putrescibility (for the plant which does not run B.O.D. tests).
g. Biochemical oxygen demand.
h. Dissolved oxygen.

All but *a*, *e* and *f* have been explained already in a general manner. Residual chlorine measures the amount of chlorine remaining in the sewage after a brief contact period. The putrescibility, or methylene blue, test measures the tendency of the sewage to de-

Making Refuse Pay a Profit



ATLANTA is one of the few cities in the world that makes its refuse pay dividends.

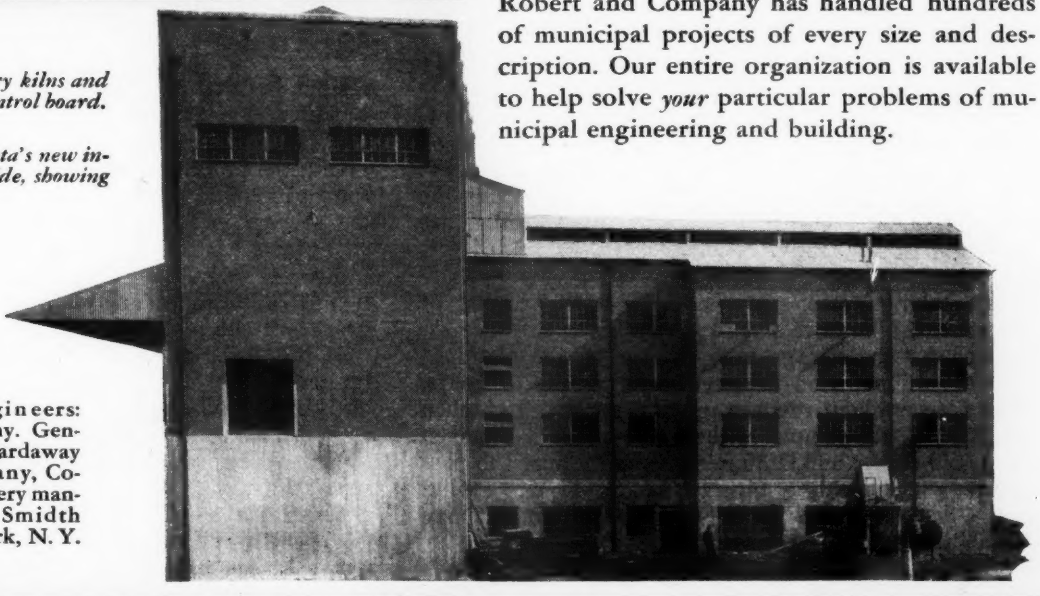
In planning the new Incinerator Plant shown here, Robert and Company, together with Atlanta's Sanitation Chief, H. J. Cates, literally searched the world for the most advanced method of refuse disposal. They found it in a newly designed plant in Denmark—a mechanically-operated, three-stage burning plant employing a rotary kiln for final burning. This new, improved principle, patented by the Volund Company of Copenhagen, was greatly superior to all other methods studied.

Atlanta's new plant—nationally-acclaimed for its efficiency in turning out revenue-producing steam — contains two complete, three-stage burning units, the machinery for which was manufactured by the F. L. Smidth Company of New York. The modern steel-and-brick plant, located in the heart of Atlanta, was erected by Hardaway Contracting Company, Columbus, Ga. The entire project was planned and supervised by Robert and Company, under Chief Cates' direction.

Robert and Company has handled hundreds of municipal projects of every size and description. Our entire organization is available to help solve *your* particular problems of municipal engineering and building.

Above—View of rotary kilns and boilers from front of control board.

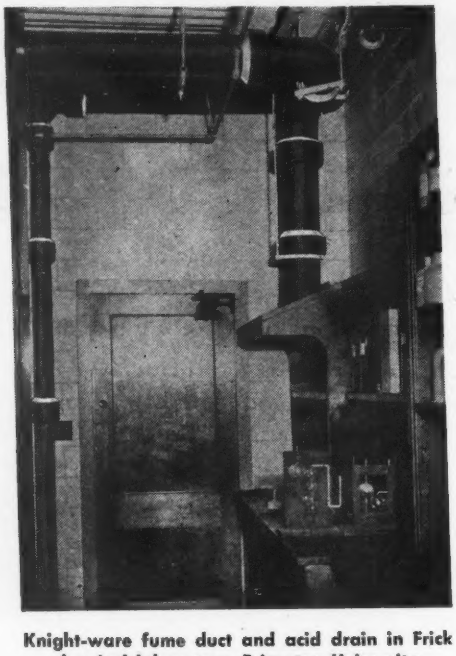
Right—View of Atlanta's new incinerator from west side, showing clinker discharge.



Architects and Engineers: Robert and Company. General Contractors: Hardaway Contracting Company, Columbus, Ga. Machinery manufactured by F. L. Smidth Company, New York, N. Y.

ROBERT AND COMPANY
INCORPORATED
Architects and Engineers
NEW YORK • ATLANTA • WASHINGTON

When you need special information—consult the *classified* READER'S SERVICE DEPT., pages 83-85



Knight-ware fume duct and acid drain in Frick chemical laboratory, Princeton University.

compose or putrefy, roughly paralleling the B.O.D. test. The total solids test measures the amount of dissolved and suspended solid matter in the sewage. Of the seven tests, all but the last two are extremely simple.

Sewage contains very great numbers of bacteria, but bacterial tests are rarely made on sewages, since it is a foregone conclusion that a very high bacterial content will be shown.

3. *Collecting Samples*—Samples may be "catch," that is a single pail or bottle full; or "composite" which are the combination of hourly or half-hourly samples taken proportionately to the sewage flow over a 24-hour period. Catch samples, though very unreliable, are frequently employed in sewage plant tests for control and guidance in operation. D.O. and pH tests must be made with fresh catch samples. D.O. samples must be taken with special equipment to prevent air from being mixed with the sample. However, hourly composite samples, the quantity based on the volume of flow at the time the sample is taken, are best. Full directions for taking and for preserving the samples during the 24-hour period of collection are given in the books already listed in Par. 1 of this section.

In taking catch samples to show the results of treatment, allowance should be made for the time required for the sewage to pass through the plant. If the detention period in a settling tank is 2½ hours, and the sample of raw sewage at the influent is taken at 9 A.M., the sample of the effluent should be taken at 11:30 A.M.; and if 30 minutes are required to pass through the trickling filter, a sample of this should be taken at 12 o'clock. However, actual detentions may be shorter than theoretical ones.

Try to take samples that are representative. Look the situation over and use your judgment. Utilize your knowledge of the flow in your own plant. Exclude large solid pieces. A 2-qt. enameled dipper or a small pail, or both, are suitable for collecting samples. Arrange to make tests promptly. More information on this will be given in connection with testing, but in general, tests should be made within 2 or 3 hours. See the books already listed.

4. *Settleable Solids* — This test measures the amount of material that will settle out of the sewage; 2 hours is the usual standard time. The amount settled out may be considered as approximating the amount that can be removed by plain sedimentation.

Two or more Imhoff cones (Fig. 2) are used. These are marked near the top with a ring to indicate 1 liter or 1000 ml. (1.05 quarts) and at the bottom are graduations so that 50 or 100 milliliters can be read quite exactly.

These cones are filled with well-stirred sewage to the 1 liter mark; after about 15 minutes rotate the cone gently, reversing the direction of rotation 3 or 4 times. This should be repeated again about 5 minutes before the final reading. This permits material clinging to the sides to move down, and also levels out the material at the bottom.

About 90% of the settleable solids are deposited in the first half-hour, 95% in the first hour, and nearly 100% in 2 hours. The amount of deposited material may be read roughly directly by the graduations at the bottom of the cone. Its denseness should be noted.

Results obtained when the reading is made directly by means of the graduations are comparative only and usually inaccurate because the solids are rarely packed closely enough to indicate actual volume. For exact results, the liquid, called the *supernatant,* should be drawn off and the total solids determined as described below; also the total solids of the settled material. From these, the proportion that settles can be computed easily.

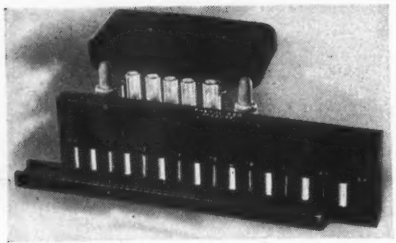
This test should be made at the same hour each day, and in exactly the same manner. Additional samples taken at other hours are often valuable checks. Note results in milliliters per 1000 mls. or, better, in ppm. Keep the cones clean with a long-handled brush, hot water and soap; grease on the inner walls interferes with good settling.

5. *Total Solids*—The total quantity of solids in a sewage is determined by evaporating a known volume of sewage, as described in *Standard Methods,* and weighing the dry residue. A sample of 100 ml. is generally used; this is evaporated to dryness in a weighed platinum, porcelain or silica dish and the residue is dried for 1 to 2 hours at 103° C. It is then cooled in the desiccator, the residue weighed in the dish, and the original weight of the dish subtracted, giving the weight of the dried residue. If the original sample was 100 ml., the parts per million of solids in the sewage is found by multiplying the weight in milligrams of the sample by 10. For example: The dish weighs 41.6012 grams empty, and after evaporation 41.7058 grams. The weight of the residue is .1046 gram or 104.6 mg. and the total solids are 1046 ppm.

If this dried residue is then heated to redness (or ignited) most or all of the volatile or organic matter is burned off and the remainder represents approximately the amount of inorganic matter in the sample. Computations are made in the same manner as for total solids.

6. *pH Value*—The alkalinity or acidity of sewage is generally measured only by its intensity, which is shown by its pH value. The neutral point—neither acid nor alkaline — is indicated by pH 7. Smaller numbers indicate acidity, and the smaller the number, the more intense the acidity. Thus 6.4 is acid, 6.0 more acid, and 5.5 even more so. Numbers from 7 to 14 indicate alkalinity; 7.6 is slightly alkaline, 8.0 more alkaline and 9.2 still more intensely alkaline.

Indicators have been developed which show pH by electrical means or by different shades of color. For sewage plant work the electrical equipment is excellent



Taylor-Enslow Slide Chlorimeter.

since it is not influenced by color or turbidity of the sewage.

Determinations of pH values are useful in sludge digestion and treatment (See Sect. VIII, par. e); necessary in chemical coagulation; and desirable in ordinary plant operation. A daily record should be made at some selected hour—the same every day. Additional tests at different hours to show variations in the sewage pH are valuable from time to time. As a rule pH increases throughout the forenoon, as does the alkalinity. (The Editor would be glad to have hourly pH and alkalinity records on sewage for several days of the week from a number of plants.)

7. *Residual Chlorine*—When chlorine is fed into sewage, the amount required is determined by the amount of chlorine remaining in the sewage 15 minutes after it has been applied. Experience has shown that if there is a residual of about 0.5 ppm., after 15 minutes, the dosage of chlorine has been sufficient.

The test most commonly used employs orthotolidine as a color reagent. The orthotolidine solution can be purchased from the manufacturer of the chlorinator, from laboratory or chemical supply firms, or made up as directed in "Standard Methods."

The test is best made by means of a chlorine comparator, available from laboratory supply firms, or it may be made with bottles, test tubes or Nessler tubes in the laboratory. Place 100 cc of sewage in a Nessler tube or bottle, allowing it to stand until 15 minutes after the chlorination, unless 15 minutes has already elapsed since the chlorine was applied. Add 1 cc. of orthotolidine solution, mix and allow to stand 10 or 15 minutes. In cold weather warm slightly. Note the color. A color scale is desirable for comparison; comparators have such color standards. In general a lemon yellow coloration indicates a proper dosage.

The starch iodide test may also be used. For details see "Standard Methods."

The test for residual chlorine should be made daily or oftener at a standard time and results recorded.

8. *Methylene Blue or Putrescibility*—This test measures the stability of a sewage effluent, that is, the length of time that elapses before the sewage putrefies. The test is particularly adapted to treated effluents, as those from trickling or sand filters. It cannot be used for sewage or effluents that have been chlorinated, therefore samples for the test should be taken before chlorination. While the relative stability measures approximately the biochemical oxygen demand, results obtained by it cannot be converted into B.O.D. results.

The methylene blue solution is made up (see Standard Methods) or purchased ready for use. In making the test, a bottle with a glass stopper must be used; an 8-ounce bottle is a good size. Fill the bottle completely, preferably by immersing or by a siphon; avoid agitation and the introduction of air bubbles. An air bubble in the bottle makes the test worthless or misleading. Add to the 8-oz. or 250-cc. bottle, 0.7 cc. of methylene blue; to other size bottles in proportion. See that no

Relative Stability to Methylene Blue

Ratio of Oxygen Available to Oxygen Required for Temperature of 20° C.

Days Required for Decoloring	*Relative Stability*	*Days Required for Decoloring*	*Relative Stability*
½	11	6	75
1	21	7	80
1½	30	8	84
2	37	9	87
2½	44	10	90
3	50	11	92
4	60	12	94
5	68	13	95

air bubbles remain under the stopper. Hold the bottle in an incubator at 20° C. (68° F.) until the blue color disappears. If no incubator is available, the sample can be kept at room temperature, which is ordinarily about 20° C., or in water. Incubation at 37° C. will give quicker but less accurate results. Note the time in days required for the sample to lose its color, and from the accompanying table note and record the relative stability.

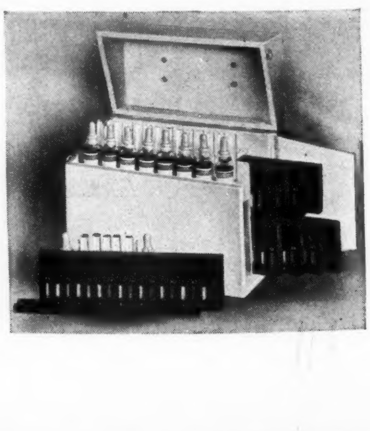
When a temperature of 37° C. is used, exactly one-half as many days are required, and the foregoing table can be used for reading the results. For instance, if decolorization occurs in 3 days when incubated at 37°, results are the same as for 6 days at 20° (or 75%). If decolorization occurs in 1½ days at 37, results are the same as for 3 days at 20° (50%).

9. *Biochemical Oxygen Demand.*—This, usually abbreviated to B.O.D., shows the oxygen required in parts per million to stabilize the decomposable organic matter in the sewage. See also Sec. III, par. 4; 5-day B.O.D. tests are commonly employed in recording the results of operation.

This test employs small quantities of sewage (in raw sewage dilutions of 99% to 99½% of distilled and aerated water are usual), and considerable care along with proper technique, are required for accurate results. Because of these factors, methods of making the test will not be given here. It is recommended that operators arrange with their state boards of health for instruction and, if possible, take one of the short courses provided, usually at the state universities. Complete details of both tests are given in the 1936 edition of *Standard Methods.* If the operator desires to make the test, each step as outlined in *Standard Methods* should be carefully studied in advance. It is recommended that if this be done, a careful record of results be kept for comparison and checking.

The presence of chlorine, unless neutralized and the sample seeded, makes results unreliable. For neutralization and seeding procedures see Standard Methods and Theroux, Eldridge and Mallmann.

Dissolved Oxygen.—On raw sewage, the dissolved oxygen (abbreviated D.O.) test measures the amount of oxygen remaining in the sewage, and is an indicator of the freshness of the sewage. It is also used on effluents, especially from trickling and sand filters and activated sludge plants, and in determining stream con-



Taylor Long Range pH Slide Comparator.

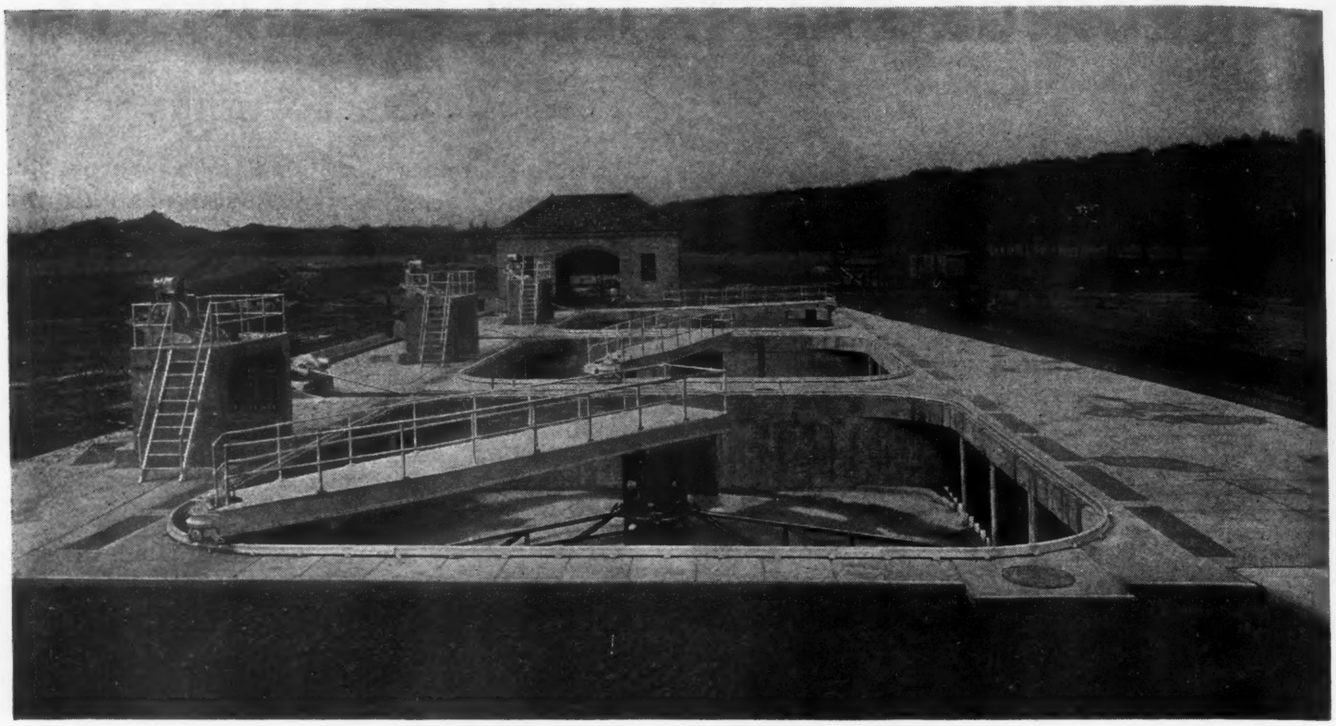


Fig. 4. Dorr Detritor installation at Baltimore, Maryland.

ditions. Analyses of samples taken in a stream above and below the sewer outlet indicates the effect on the stream of the sewage discharge.

This test is also a part of the method of determining B.O.D. and the same comment applies as to the B.O.D. test in regard to learning procedures.

10. *How to Report Tests.*—For all results but those for nitrogen, results are tabulated as follows: For ppm. between 0.1 and 1, use two decimal places, as 0.57; between 1 and 10, use one decimal place, as 6.2; between 10 and 100 use the nearest whole number, as 86; over 100, use only two significant figures, as 140, not 143. When reports are tabulated, do not add zeros to the right of the decimal point to balance the columns.

V.—Operating Grit Chambers and Coarse Screens

1. *Grit Chamber Operation.*—All sewage carries in suspension some sand, grit, and cinders. Combined sewers (those that carry both storm water and house sewage) carry most, but even in the small plant treating only ordinary domestic sewage, a considerable amount of coarse material arrives in the sewage. In Imhoff tanks this makes the sludge hard to handle, and in separate sludge digestion tanks it may cause the same trouble also. When sewage is pumped, such material causes rapid wear in the pumps.

Sand or grit may also clog or interfere with the working of valves and gates and, where there are inverted siphons, may wholly or partially clog these.

(a) *Removal Methods.*—The sand, cinder particles and similar material being heavier will settle more quickly than the organic matter in the sewage. Removal is therefore accomplished by providing area for settling and reducing the velocity of the sewage to about 1 foot per second, at which velocity the sand and other grit will settle, while the organic matter does not.

The flow of sewage varies, being larger during the day than at night. It is therefore difficult to design a grit chamber for all volumes of flow. In older designs this is usually accompanied by providing such grit chambers with two or more channels or compartments, one or more of which can be used, depending on the flow. In newer, mechanical units, other provisions are made.

(b) *Types of Grit Chambers.*—Older plants are commonly equipped with the type of basin shown in Fig. 3. In actual operation, except in large plants, cleaning and grit removal is difficult and disagreeable and very liable to be neglected in the average plant.

Modern devices include the Dorr "Detritor," Fig. 4, and the Link-Belt, Fig. 5, which provide for mechanical removal and washing of the grit, so that the material removed is relatively clean and unobjectionable. Jeffrey has grit removers of several types. Chain Belt uses a bucket type remover.

(c) *Operation.*—When modern mechanical equipment is used, operation consists of (1) final disposal of the washed grit, which can be used for fill; and (2) lubricating and maintaining the equipment in accordance with the manufacturer's directions.

In the older types of grit chambers, cleaning is necessary after every heavy storm, as a rule, and also when it is determined by measuring with a pole marked to feet and inches, that the channels are half full or more. In dry weather, measurements should be made once a week. Removal is accomplished by shutting off the flow in the compartment or channel to be cleaned, pumping or bailing out the sewage, and removing the residue with shovels, pails or, in large plants, with grab buckets. Such grit usually contains so much organic matter that it should be buried; but if sufficient space is available it may be dried on sludge beds at some risk of causing odors.

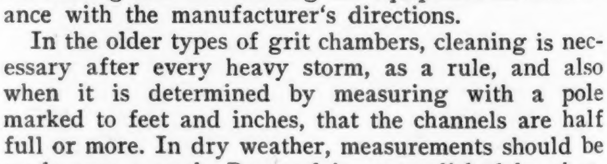


Fig. 3. Old type bar screen and hand-cleaned grit chamber.

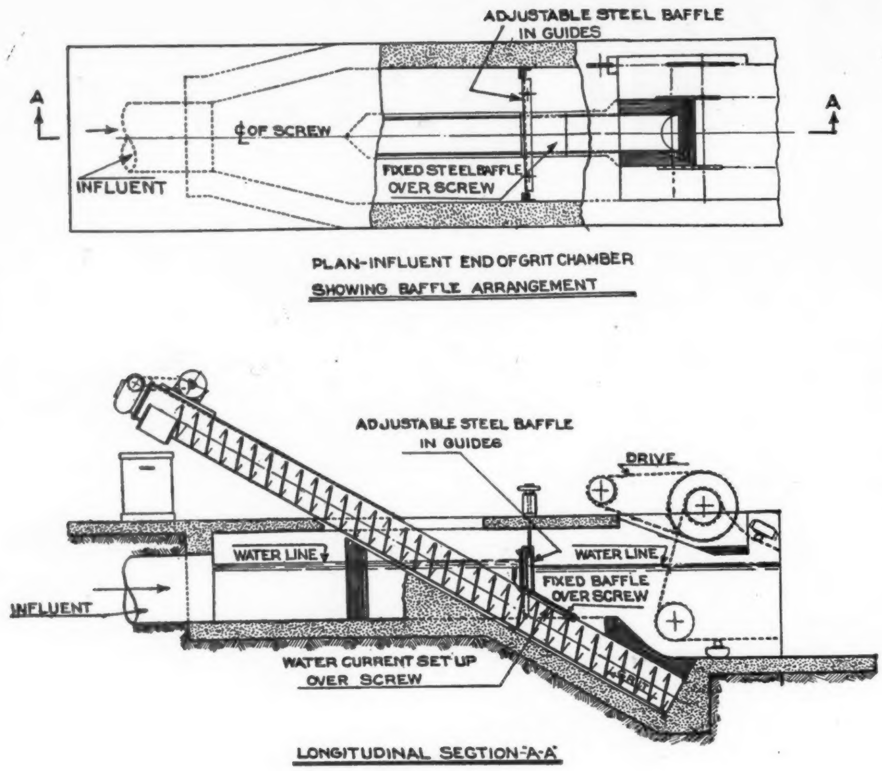


Fig. 5. Link-Belt mechanically cleaned grit collector.

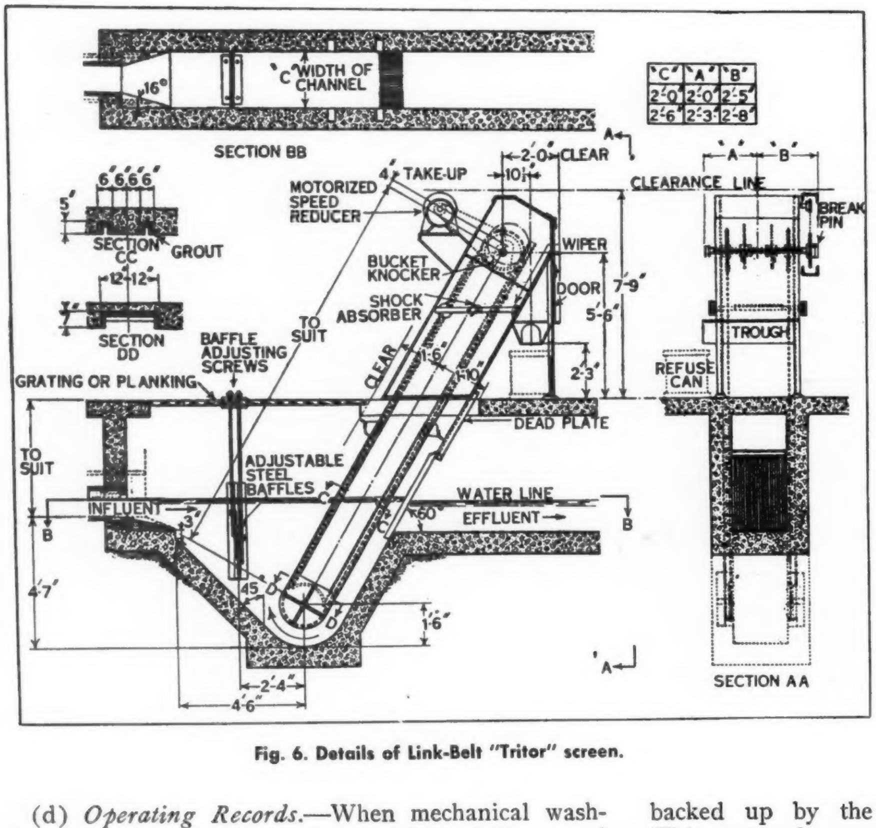


Fig. 6. Details of Link-Belt "Tritor" screen.

(d) *Operating Records.*—When mechanical washing and removal apparatus is used, a daily record should be made of the amount (generally in cubic feet) of material removed. This may be entered on the daily report in a column adjacent to the volume of flow and to the volume of screenings.

When grit chambers must be cleaned by hand, the dates of cleaning and the amount of material removed should be noted; also days since last cleaning and notations regarding storms.

2. *Screens and Screening.*—The purpose of screens is to remove large objects in the sewage. Such objects tend to clog pumps and pipe lines and to interfere with plant operation.

The term screens, as used here, refers to a screen made of iron bars spaced ½ inch or more apart. The bars are usually set at an agle to facilitate cleaning. Cleaning is done by hand, or by a rake on the mechanically cleaned screens. Hand cleaning is a disagreeable job, often neglected; mechanically cleaned screens are therefore very preferable.

On hand-cleaned screens, an area between the bars about twice as great as the area of the entering and leaving sewer is desirable.

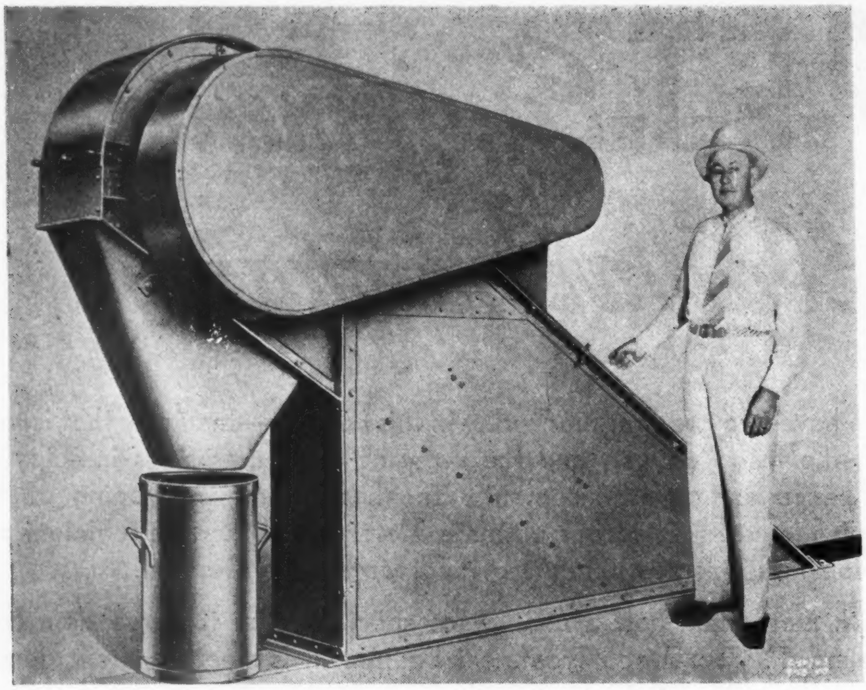
(a) *Types of Screens.*—In addition to the hand cleaned screens, there are several types of mechanically cleaned machines. These include the Tritor, by Link-Belt, Fig. 6, which is a combined grit chamber and screen. Grit and sand settle in the pocket at the foot of the screen, and are removed by means of a bucket. The edge of the bucket also cleans the screen.

Mechanically cleaned screens are made by Dorr, Jeffrey, Chain Belt, and Link-Belt.

In addition to convenience, such screens are more effective than hand-cleaned screens because cleaning is more frequent. In the small plant, screens are raked by hand only once or twice a day, as a rule, whereas the mechanical screen can be set by a timing device to operate as desired, as 3, 5, 10, 30 or 60 minutes, or intermediate intervals. As a result, about twice as great a volume of screenings is removed.

(b) *Operation of Screens.*—Hand cleaned screens should be cleaned several times a day, otherwise the sewage is backed up by the material caught on the screens. This not only may cause deposits in the entering sewer, but may also force some of the material through the screen thus rendering it less effective. The screen chamber should be hosed and squeeged weekly, or oftener in warm weather.

Mechanical screens should be lubricated in accordance with the manufacturers' suggestions. The screen, buckets, and the screen chamber should be hosed daily to keep them clean, and the chamber walls squeegeed



Head section of Chain Belt grit collector.

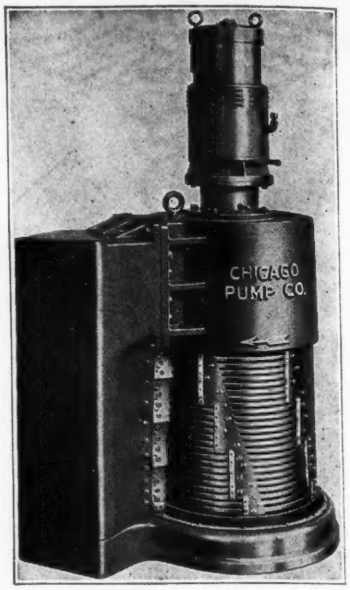


Fig. 7. The Comminutor cuts up the coarse matter in sewage as it reaches the plant.

at weekly intervals. The entire mechanism should be painted annually. Slack in chains should be taken up in accordance with manufacturers' directions. Spare links should be stocked.

(c) *Disposal of Screenings.*—The screenings removed are very disagreeable. Prompt and sanitary disposal is necessary. Grinding is a good method of disposal (see "d" below). Mechanically cleaned screens may discharge direct into wheelbarrows or into closed cans. Burial is the most common method of disposal, but in many plants such a small amount of cover is given that rats and even flies reach the material. A trench at least 3 feet deep is necessary, and spraying the screenings with creosote or covering with tar after dumping them into the trench is desirable. Cover at once and thoroughly with at least 18 inches of compacted cover. At some small plants, screenings are placed in the digester. A small incinerator is excellent for disposal.

(d) *Screening Shredders.* — There are available screenings shredders which cut or grind the screenings to small bits and return these to the sewage for final disposal by sedimentation and digestion. These are made by Chain Belt, Jeffrey, American Well Works, Gruendler, Infilco, and Chicago Pump. The last, which acts also as its own screen is the Chicago Pump "comminutor" shown in Fig. 7. The Jeffrey grinder is shown in Fig. 8, and the Infilco "Griductor" in 8a.

Grit should be removed before grinding, otherwise the cutting edges of the teeth wear and must be replaced at intervals. Teeth should be resharpened by the manufacturer before wear becomes excessive.

(e) *Records of Operation.*—Records should show the amount of screenings removed daily, which is easiest measured by noting the capacity of the wheelbarrow used and the number of times it is filled. On the mechanically cleaned screens, a record should be made of the time settling between strokes—as 5 minutes or 10 minutes; also of the amount of material removed. When the screen discharges directly into a grinder or when a comminutor is used, there is commonly no record of the amount removed, but measurements may be made at intervals for purposes of record.

VI.—Mechanically Cleaned Sedimentation Tanks

This section covers the operation of sedimentation tanks equipped with apparatus for the collection and removal of sludge. It does not refer to septic tanks, to hopper bottom settling tanks, nor to Imhoff tanks, on which a separate section has been prepared.

(a) *Purpose of Sedimentation.*—The purpose of sedimentation is to remove as much as possible of the solids carried by the sewage, specifically those that will float or settle out, to separate this material from the sewage and to treat and dispose of it separately. Such treatment does not produce a "pure" effluent; it does, however, represent a considerable step forward in the process of treatment. From 30% to 60% of the suspended solids are ordinarily removed and from 10% to 30% of the total solids.

(b) *Design of Settling Tanks.*—Settling tanks are generally circular or rectangular in shape, but some are square. The rectangular, with a length four or five times the width, and the circular are most common. Most tanks are not over 9 or 10 feet in depth, since experience has shown these are as effective as deeper tanks and cost less to construct. The capacity of the tank—the width times the length times the water depth—should be equal to the average flow of sewage over

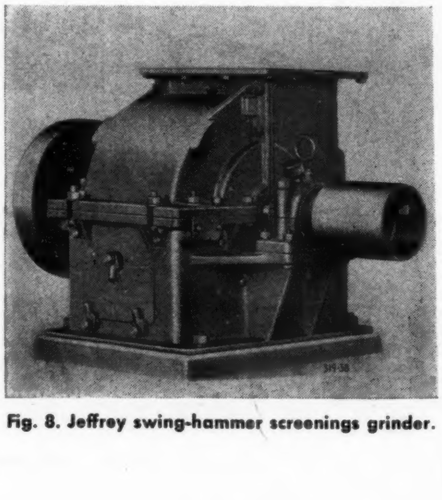


Fig. 8. Jeffrey swing-hammer screenings grinder.

a 2 or 3 hour period. For instance, a tank 70 ft. long, 10 ft. deep and 15 ft. wide has a capacity of 70 x 10 x 15 = 10,500 cubic feet, or 78,750 gallons. With a detention period of 2½ hours, such a tank would treat 78,750 x 24 ÷ 2.5 = 756,000 gallons per day.

A circular tank 40 ft. in diameter and 10 ft. deep has a capacity of 40 x 40 x .7854 x 10 = 12,656 cu. ft. or 94,250 gallons, and with a detention capacity of 2.5 hours, would treat about 905,000 gallons per day.

To find the capacity of your own rectangular settling tanks in gallons, multiply the length times the width times the water depth by 7.48; and, in the case of circular tanks, the diameter times the diameter times the depth times .7854 times 7.48.

Tank area is also important; primary settling tanks normally are rated at 800 to 1000 gallons per sq. ft. of surface area for 24 hours.

(c) *Types of Tanks.*—The types of tanks mentioned are represented by the Dorr, Link-Belt, Hardinge, Infilco and Chain Belt circular tanks, and the Dorr Monorake, Link-Belt, Jeffrey, American Well Works, Chain Belt and Hardinge rectangular. Fig. 9 represents the Dorr tank. The sewage enters through the inlet pipe at the bottom, and is fed into the tank through the diffusers, the openings being near the bottom of the central feed. It then flows slowly to the edges of the circular tank and over a circular outlet weir into a channel, the settleable solid matter meanwhile settling to the bottom. A revolving arm, to which is attached scrapers, collects this settled matter or sludge to a sump at the center of the tank from which it is removed by means of a sludge pump.

Fig. 10 represents a Link-Belt Straightline settling tank. The sewage enters through the influent channel and into the tank through slots in the end wall, passing slowly through the tank, under the scum-trough and baffle at the end and into the effluent channel. The solids that settle to the bottom are collected in the sludge hopper at the influent end of the tank by means of scrapers or flights attached to endless chains, as shown in the illustration; and these flights are so arranged that they also scrape the scum that collects on the surface of the sewage in the tank to the scum trough at the outlet end of the tank, whence it can be removed by the operator.

The Chain Belt and Jeffrey tanks are very similar to the Link-Belt tanks, differing only in details.

Operation of Tanks.—Sludge is removed continuously in some plants, and two to four times a day in others. Continuous removal reduces floating scum and may result in thicker sludge.

The sludge is drawn from the sludge sump in the bottom of the tank by means of pumps, which also usually operate twice a day on small plants and continuously on large ones, discharging sludge into the digestion tank. In this type of operation, the operator should take frequent samples of the sludge being drawn (provision is usually made for easy sampling) and adjust the pump capacity so that the sludge is drawn, but no more. If sewage is being drawn, the pump should be regulated to draw from the tank at a slower rate.

When the collectors are run intermittently, as for one hour twice a day, the pumps should be started after one-half revolution of the scrapers and should be allowed to run as long as they draw good sludge from the tank. Collectors should be stopped when the sludge becomes thin.

A common trouble is excessive pumping to digesters, resulting in digestion difficulties, too much supernatant and a heavy load on secondary treatment processes.

When the sludge is drawn by hydrostatic pressure, that is by the pressure of the sewage in the tank, the valve on the pipe is opened part way, and the sludge allowed to flow out; when the sludge becomes thin, the valve should be closed. Most plants utilizing this method are so designed that the operator can see the

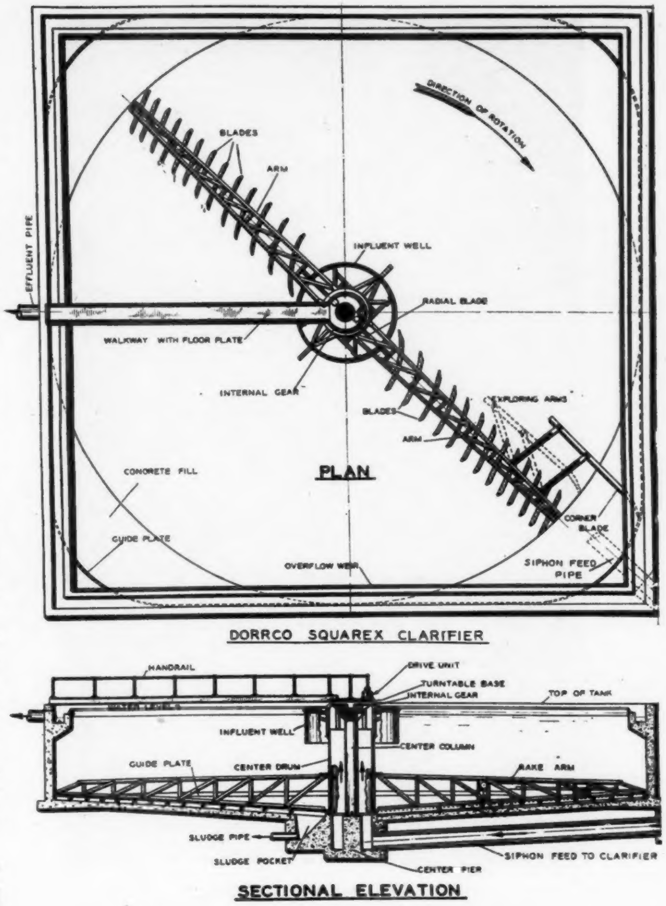


Fig. 9. Dorrco "Sifeed" (siphon feed) Clarifier, "Squarex" type. These are more commonly made with circular rather than square containing walls.

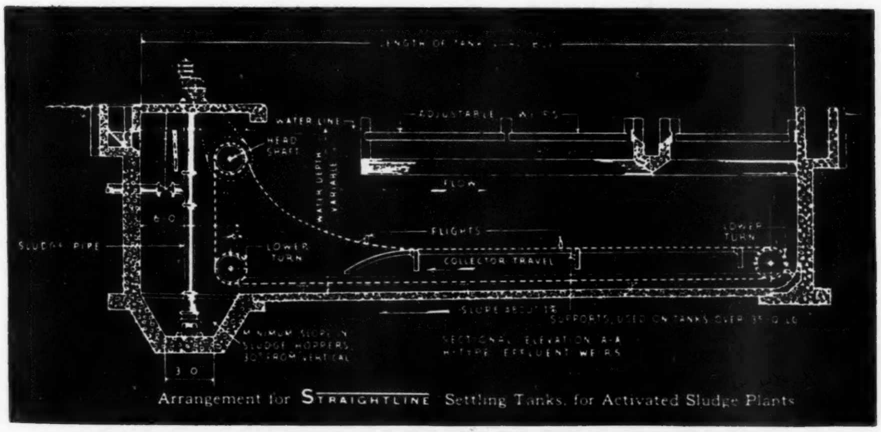


Fig. 10. Details of "Straightline" settling tank for activated sludge plant installation.

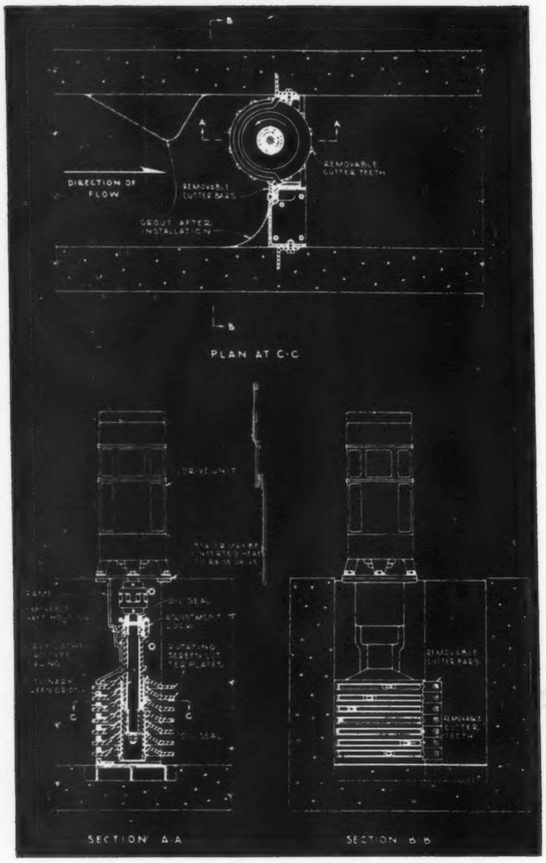


Fig. 8a. The Infilco "Griductor."

sludge as it is being drawn, and can judge when the valve should be closed.

Some floating material collects on the top of the tanks. Mechanical apparatus is now commonly used to remove such material. Where it is not available, hand removal at least once a day is necessary. Appearance is the principal factors for guidance in this. Skimmings are usually placed in the sludge digestion tank. Most plants are so designed that these skimmings may be swept into a trough which discharges into the digester or into the pump sump so that further handling is not necessary. See the section on Imhoff tanks for handy skimming tools.

The side walls of the settling tank sometimes collect fine solids, which in warm weather decompose; also at the water line, some grease is deposited. This should be removed daily with a stiff brush or with a squeegee, and the walls washed down with a hose, care being taken not to disturb the tank contents more than is necessary. It is desirable to squeegee the side walls of the tank to prevent the deposit there from peeling off and coming to the surface as dark floating pieces of organic matter. This is not easy, but is necessary in warm weather. Rising gas bubbles indicate improper or inadequate sludge removal.

The inlet channel should be washed out with a hose every day and scrubbed at least once a week, using a stiff broom; the same treatment should be given to the outlet channel and to the baffle.

Manufacturers furnish with their equipment a lubrication chart which shows where to oil and grease and tells what kind of lubricant to use. These instructions should be followed very carefully. The motors and reducers are complicated pieces of apparatus, and even though the collector itself travels slowly, this is only because of gear reducers, parts of which travel at a high speed. If the lubrication chart has been lost, write to the manufacturer of the sludge collecting apparatus and ask for another one.

It is good policy to empty a tank every six months, inspect the machinery and make necessary adjustments. This is especially the case with new plants, as takeups and scrapers may need adjustments. Sewage should not be by-passed into a stream during inspection, if possible; otherwise it may be by-passed during periods of very high streamflow.

Mechanical equipment should be kept well painted.

Records of Operation.—For sedimentation tanks of this type, the records of operation should include at least the following: When and for how long the collecting apparatus is run; volume of sludge removed, preferably in cubic feet per million gallons; the solids content of the raw sludge; temperature of the sludge removed; pH of the sludge; and settleable solids daily of both the raw sewage and the tank effluent.

VII.—Activated Sludge

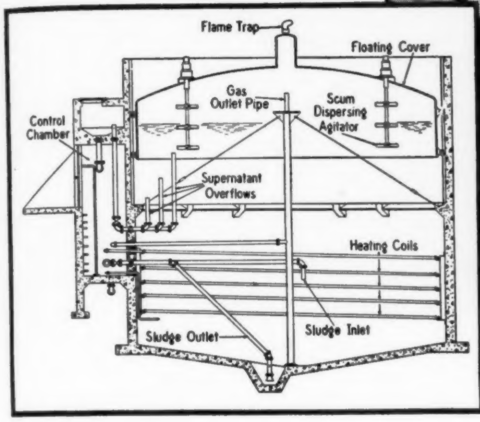
(a) *General.*—There are two general types of activated sludge plants—diffused air and mechanical. General features of operation are similar. The sewage is settled in sedimentation tanks and the partly clarified effluent then flows into aeration tanks. As the sewage enters the aeration tanks, activated sludge is added to it. This sludge, which in volume amounts to 20% to 30% of the sewage flow, is drawn from the final settling tanks. After passage through the aeration tanks, which requires 5 to 7 hours, during which time the sewage-sludge mixture is continually aerated, it is discharged to the final settling tanks. A considerable portion of the sludge collected in the final settling tanks is to be returned to the inlet of the aeration tank; the remainder must be disposed of by digestion or other means.

Air for agitation and aeration is supplied, in the case of diffused air plants, by means of blowers which force air through specially constructed diffusers in the bottoms of the tanks; and a similar action is obtained in mechanical plants by aerators. Agitation is necessary to keep the mixture of sludge and sewage in motion, so that the particles will not settle and so that the activated sludge particles have intimate contact with sewage. Air, either diffused as very small bubbles, or obtained from the atmosphere by mechanical aeration, is necessary to maintain aerobic conditions in the plant.

(b) *Operation of Sedimentation and Aeration Units.*—Since the action in an activated sludge plant is biochemical, conditions in the aeration tanks should

Three sedimentation tanks at New Haven, Conn., sewage works, in which all concrete and steel surfaces are protected by Inertol.

Sewage Equipment by GRAVER



A Complete Service and an Undivided Responsibility

- AERATORS
- AGITATORS
- AUTOMATIC DOSING SIPHONS
- CHEMICAL FEEDERS
- CHEMICAL PROPORTIONERS
- CHEMICAL TREATMENT PLANTS
- CLARIFIERS, PRIMARY AND SECONDARY
- COAGULATORS
- DIGESTERS
- GREASE REMOVAL EQUIPMENT
- GAS HOLDERS
- IMHOFF COMBINATION CLARIFIERS
- REACTIVATOR CLARIFIERS
- ROTARY DISTRIBUTORS
- SKIMMERS
- SLUDGE CONDITIONERS
- SLUDGE DRYERS
- SLUDGE FILTERS

Sanitation engineers know that the successful operation of a sewage plant depends upon the proper functioning of each of a myriad of parts which go to make up the whole. And further, that this is only accomplished by constant control in production from drawing board to installation.

Graver Sewage Equipment is completely designed and manufactured by Graver engineers and workmen. And behind these men is more than thirty years of experience in the design and manufacture of special equipment for thousands of institutions, industries, and municipalities, including more than ten years of experience with sewage equipment.

In selecting Graver equipment for the treatment of sewage you have the advantage of a complete service and an undivided responsibility, soundly based upon competent engineering and modern manufacturing methods.

Get the facts about this service today. Write for bulletin No. 311.

• Photo above shows, in foreground, two 75 feet diameter Graver Digester Floating Covers. Diagram shows sectional view of Graver Digester.

GRAVER

GRAVER TANK & MFG. CO., INC.

NEW YORK
CATASAUQUA, PA.

4809-15 TOD AVE.
EAST CHICAGO, IND.
CABLE ADDRESS — GRATANK

CHICAGO
TULSA

42-50-W

"Chicago" Air Diffusion System with Swing Diffusers at the Omaha, Nebraska, sewage treatment plant. Each Swing Diffuser unit can be raised completely out of the tank for tube inspection, maintenance and regulation of air supply without dewatering the tank or interrupting operation.

be maintained on a uniform basis at all times. Heavy loads of strong sewage; strong overflow from the digester, or supernatant; or large and rapid increases in flow of sewage must be cared for by providing an adequate return flow of active sludge. Where possible, supernatant liquor that contains 3,000 ppm. or more of suspended matter should be disposed of otherwise, or pretreated, before discharge into the settling tank.

Frequent tests for dissolved oxygen should be made on the plant effluent and in the aeration tanks. The presence of more than 4 or 5 ppm. may indicate over aeration or an improper distribution of air. Most air should be supplied at the inlet end of the aeration tank—plants are usually designed to apply one-half of the air in the first 25% of the tank length. This tapered application of air is desirable for economy and effectiveness of operation.

The control of solids in the aeration tank liquor is important. Since each activated sludge plant is a law largely unto itself, each operator must determine from his own personal experience at his plant the amount of solids that gives the best and most economical results. If the solids content is too great, the air supply may be deficient and inferior treatment may result. If there is a deficiency of solids—that is, not enough to produce the necessary concentration of activated sludge in the aeration tank, inadequate treatment will result. Under usual conditions at most plants, 2,000 to 3,000 parts per million of solids are carried in the aeration-tank liquor of diffused-air plants, and 300 to 900 ppm. in mechanical aeration plants. As previously stated, this factor must be varied with the strength of the sewage.

Thus activated sludge must be added to the incoming sewage, as it enters the aeration tank, on the basis of volume of flow as well as strength of sewage. Sludge must be stored in the final settling tank to meet these needs, but since the stored sludge deteriorates rapidly, good management is necessary, as well as a knowledge of local conditions of flow, strength, etc.

(c) *Bulking.*—The sludge index (see the books listed in Sect. IV, Par. 1) test, in diffused air plants will normally give values between 50 and 150 and in mechanical-aeration plants between 200 and 300. An exceptionally large value for the sludge index generally indicates that bulking is taking place in the final settling tanks. When bulking occurs, the sludge particles are large and fluffy and may tend to rise instead of settling. Bulking may be caused by the growth of a thread-like fungus, by an unbalanced condition in the microscopic life existing in the aeration tank, by industrial wastes, or sometimes by the introduction of a stale or septic sludge, which probably tends to cause the unbalanced condition just mentioned. The cause of bulking should first be determined. If the fungus growth is the cause, reduction of the pH to 6.5 will eliminate the fungus; chlorination of the return sludge, or the addition of lime have been helpful. Chlorine dosages up to 6.0 or 7.0 ppm. have been successful, but smaller application should be used initially.

(d) *Operating Records.*—In addition to the general records already discussed, records on activated sludge plant operation should include: The amount of return sludge; the sludge index; D.O. and nitrates in the plant effluent; and a record of the results of each plant unit.

VIII.—Imhoff Tanks

The Imhoff tank acts both as a sedimentation tank and as a sludge digestion tank. It is, in effect, a two-story tank. The upper part is a settling tank; the lower part stores and digests the solids that settle out of the sewage. These pass through a trapped slot in the bottom of the settling compartment and are retained in the sludge compartment until digestion has progressed far enough so that the sludge may be dried on sand beds. The sketch herewith (Fig. 11) illustrates the three important parts of an Imhoff tank—the settling compartment, the sludge compartment and the gas or scum vents.

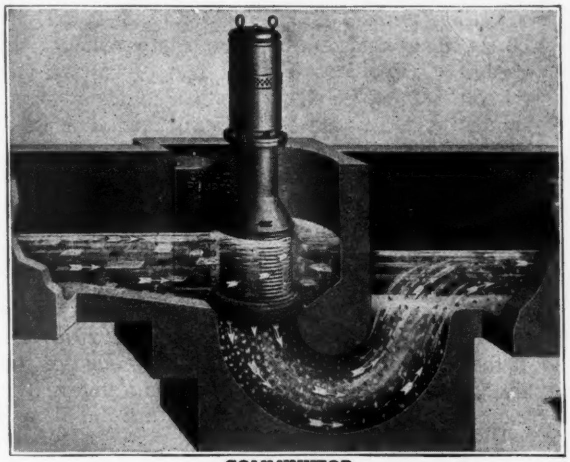
The settling compartment is designed to provide a

All Operators Praise

COMMINUTOR • FLUSH-KLEEN • SCRU-PELLER

For Automatic, Trouble-free Handling of Sewage . . . Eliminating Most Common and Usual Troubles in Sewage Plants and Lift Stations

That's Why Over 300 Engineers Specified 750 Comminutors 2,500 Flush-Kleens and 500 Scru-Pellers



COMMINUTOR
Automatic Screening and Cutting of All Coarse Sewage Matter

COMMINUTORS provide subsurface automatic screening and cutting of coarse solids without removal from channel.

No screenings odor or fly nuisance.

No manual labor for collection and disposal of screenings.

No clogging of mechanical equipment by coarse solids.

Reduces scum formation and floating solids.

FLUSH-KLEENS can't clog. Solids do not pass through the impellers. Operation is automatic.

FILLING WET WELL

① Sewage flows through inlet pipe.

② Coarse sewage matter is retained by strainer.

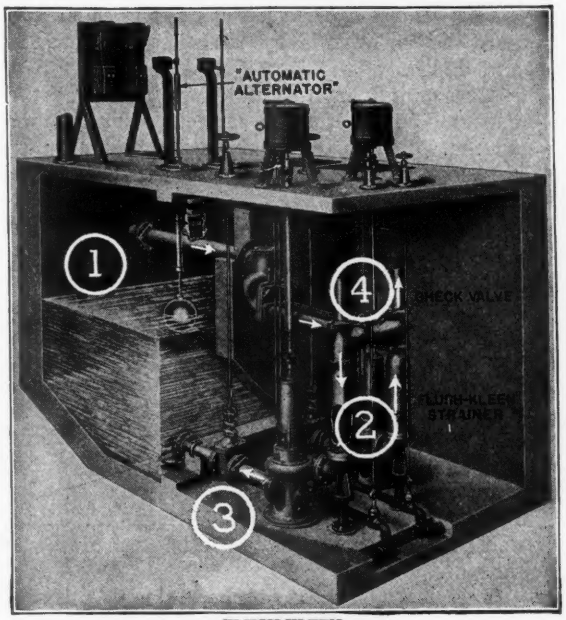
③ Strained sewage flows through idle pump to basin.

PUMPING

③ Strained sewage is pumped from basin.

② Coarse sewage matter is backwashed from strainer.

④ Special check valve closes; sewage and coarse matter are pumped to sewers.



FLUSH-KLEEN
Rags and Other Coarse Solids Do Not Pass Through Impeller

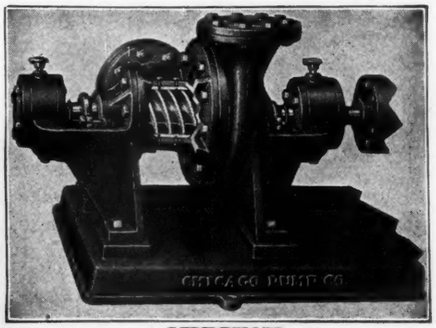
SCRU-PELLER was designed especially for pumping primary sludge. Also effective in handling raw sewage.

The only cutting pump with ball bearings on both sides of the impeller and built STURDY enough for severe shocks.

It is a centrifugal pump with a cutting screw feed in the suction. Cutting edges on the screw and in its housing shear solids that clog ordinary pumps.

The only pump providing continuous multiple shearing actions all the way through the pump.

Ask for Bulletins 185, 122 and 190.



SCRU-PELLER
Centrifugal Pump With Cutting Screw Feed

CHICAGO PUMP CO. SEWAGE EQUIPMENT DIVISION

2336 Wolfram Street, CHICAGO, ILL.
Phone BRUnswick 4110

VACUUM – CONDENSATION – CIRCULATING – BILGE
FIRE – HOUSE – SEWAGE – SCRU-PELLER PUMPS
AERATORS – COMMINUTORS – SAMPLERS

REPRESENTATIVES THROUGHOUT THE UNITED STATES AND FOREIGN COUNTRIES

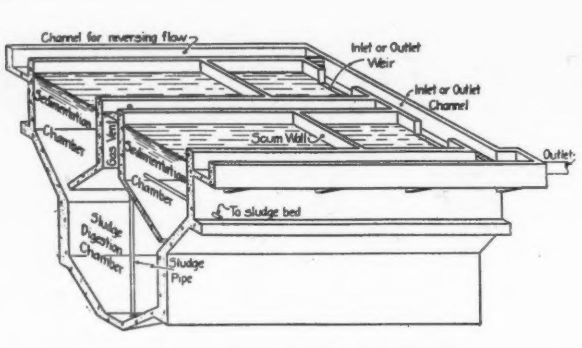


Fig. 11. Sectional view of Imhoff tank.

retention period of 1½ to 3 hours—usually about 2 hours. The sludge digestion compartment is usually designed with 3 to 4 cubic feet of capacity for each person it is expected to serve. The scum or gas vents should have an area of from 20% to 30% of the area of the tank surface.

(a) *General.*—The inlet and outlet channels should be kept clean with a scrubber or squeegee and hose. Some Imhoff tanks are equipped with channels and gates for reversing the flow. Such gates and channels should also be kept clean, and the flow should be reversed about twice a month. The heavier and bulkier solids in sewage settle quickest. Therefore that part of the tank nearest the inlet receives most of the solids and may fill and require emptying before there has been time for digestion. Reversing the flow aids in getting equal deposits of sludge.

(b) *Sedimentation Compartments.*.— As already stated, this compartment should be large enough to give a detention period of at least 1½ hours. The operator can check this by measuring the width, length and depth.

Grease and scum should be skimmed off the surface generally daily, though careless skimming may break up the solid matter in the scum and permit it to be carried out in the effluent. F. E. Daniels says that many times it is better to allow scum to accumulate, removing it at less frequent intervals. A skimmer and some other tools are shown herewith, Fig. 12. (Many of the tools shown in the figure have wooden handles. These are undesirable, as the flotation may make them jump back into the operator's face. An iron pipe handle is better, even if it is heavy.) The materials skimmed off may be placed in the gas vents, or burned or buried. The sides, ends and sloping bottoms of the sedimentation compartment should be scraped frequently—every day or every other day in warm weather and weekly or twice a week at other times. A squeegee is also shown in Fig. 12. The material that clings to the walls should be pushed down through the slot.

The slot should also be kept clean. A chain drag is sometimes used for this purpose. The slot should be cleaned from one to three times a week.

In cleaning the walls and slot, unnecessary turbulence or stirring up should be avoided. The material in the sludge compartment should not be brought up into the settling compartment. The Imhoff tank is designed to keep the decomposing material in the lower chamber out of contact with the sewage in the settling chamber, as experience has shown that better settling and a fresher effluent easier to treat on trickling filters or contact or sand beds results from this separation.

(c) *Gas Vents and Scum Compartments.*—Floating solids from the digestion chamber rise into these openings; also gas produced by the digestion of the sludge escapes through them. The scum may become very heavy at times. It is desirable that this floating material be broken up from time to time to permit the escape of gas and prevent the formation of solid masses of dry or partly dry material.

This breaking up of heavy material in the gas vents can be done with a rake or hoe; by using a fairly large hose under considerable pressure; or by pumping sewage from either the settling or sludge compartment with a small force pump. It is best to draw sewage from the upper part of the digestion chamber because this is returned through the gas vents and does not tend to cause flow between the upper and lower compartments. For the same reason, too much water should not be used.

The scum, if quite dry, may be removed with shovels and placed on the sludge drying bed for complete drying out.

Lime may be added; New York State recommends 10 pounds of hydrated lime per day per 1000 population. This can be applied as a solution and well mixed, or washed in well with a hose. The addition of lime also aids in maintaining an alkaline reaction, which is desirable for proper sludge digestion.

In cold weather, when the scum tends to freeze, holes may be punched through it to allow the gas to escape.

(d) *The Sludge Compartment.*—The sludge digestion compartment is inaccessible, as well as out of sight. Therefore operation must be based on pH and appearance of sludge and on soundings to determine the depth of the sludge deposit.

The pH of the sludge should generally be 7.2 to 7.6. An acid sludge may result in foaming, which is discussed hereafter. Well digested sludge is usually dark, rather granular and without disagreeable odor.

The depth of sludge may be determined: 1. By a pitcher pump with a weighted suction hose marked at 1- or 2-ft. intervals. Lower the hose through the gas vent or slot, working the pump handle. When thick sludge comes through the pump, or the pump chokes, as it usually will with thick sludge, the depth is determined; 2. A weighted wooden block, or iron plate 12 ins. square is lowered. Reduction in weight on the graduated chain or wire indicates depth. (This is not generally very satisfactory.) 3. A metal can or bottle, with a stopper and spring fastened to a rod; the stopper is pulled out with a wire.

Sludge should be drawn whenever it approaches within 18 ins. of the bottom of the slot or trap in the sedimentation chamber.

(e) *Drawing Sludge.*—Sludge should be removed at a slow and regular rate; at comparatively frequent intervals; and not all the digested or ripe sludge should be removed. Usually not more than one-half of

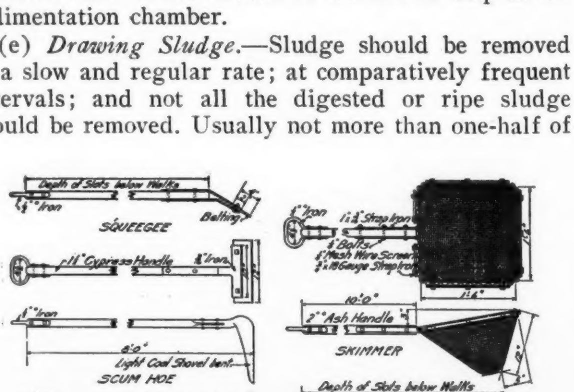


Fig. 12. Operators' tools for Imhoff tanks. Suggestions of Pacific Flush Tank Co.

REX SANITATION EQUIPMENT . . .

Choice for Outstanding Plants!

STRONGEST recommendation for the application of REX Sanitation Equipment to your military, municipal, industrial, or trade waste disposal problem is the impressive list of installations where REX equipment is being used with above-average success. The fact that REX Sanitation Equipment is more and more frequently the choice for outstanding projects—large and small—and the continued preference by leading consulting engineers—points directly to REX as a leader in this field. Many years' experience plus a staff of capable engineers will make your inquiry worthwhile. Get in touch with the REX Man and get any and all catalogs covering REX Equipment which interest you by writing 1722 West Bruce Street, Milwaukee, Wisconsin.

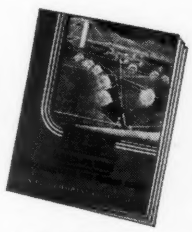
	NO. UNITS	NO. PLANTS
Conveyor Sludge Collectors	900	304
Tow-Bro Sludge Removers	66	27
Grit Collectors	93	39
Mechanically Cleaned Bar Screens	150	107
Triturators	100	77
Slo-Mixers and Flash Mixers	72	31
Aero-Filters	17	12

Catalogs Sent At Your Request

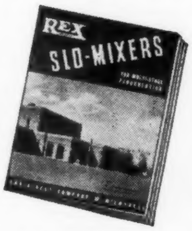
Catalog 319—Rex Mechanically Cleaned Bar Screens & Triturators

Catalog 309—Rex Conveyor Sludge Collectors

Catalog 279—Rex Tow-Bro Sludge Removers



Catalog 329—Rex Aero-Filters



Catalog 389—Rex Slo-Mixers and Rex Flash Mixers

REX CHAIN BELT COMPANY of Milwaukee

the depth of sludge should be removed at once; less is better.

Sludge in an Imhoff tank tends to become quite solid and firm, especially where there is much silt or sand in the sewage. If the sludge is drawn at a rapid rate, a hole may be formed that will draw undigested sludge or even sewage, while some of the digested sludge remains in the hopper.

Drawing of sludge is best accomplished by opening the draw-off valve part way, meantime pushing the sludge toward the bottom of the hopper with a long rod having a cross piece attached. A hose may be let down through the sludge pipe and water forced through to loosen the sludge. Care should be taken to have a vacuum breaker on all water connections to a sewage plant. Otherwise a hose so used and left immersed would constitute a dangerous cross-connection to the water supply. In summer, sludge normally will be drawn about once a month; in the winter only when the sludge in the tank reaches within 18 inches of the slots. After the sludge is drawn, the sludge piping should be flushed out with water and, where freezing is no hazard, the pipes should be left full of water to prevent sludge hardening in and clogging the pipes. It is often advisable to draw down the sludge in the late summer and fall to provide storage space for the winter.

(f) *Foaming.*—Gas vent contents sometimes become light and foamy and literally "boil over." This condition is called "foaming." It may be caused by industrial wastes from milk plants, canneries, breweries, etc., which turn sour in the tank; or it may be caused also by drawing too much sludge, by overloading the sludge chamber, by rapid increases in temperature of the sludge; or by other reasons.

If the cause can be determined it should be removed. If diagnosis of the trouble is not possible, various remedies may be tried, including: Putting the tank out of service temporarily, if another is available; drawing a small amount of sludge; adding lime through the gas vents; breaking up the foamy scum; prechlorination of the sewage, using three to ten ppm. of chlorine.

(g) *Operation Records.*—The following records of Imhoff tank operation are desirable:

1. Settleable solids in raw sewage and in effluent, daily, by means of Imhoff cones.
2. Record of skimming sedimentation compartment.
3. Record of cleaning slots.
4. Record of breaking up scum.
5. pH of sludge (daily or weekly record).
6. Amounts of sludge drawn and dates of drawing.
7. Moisture and volatile contents of sludge.
8. Record of sounding for sludge depths.

IX.—Trickling Filter Operation

A trickling filter consists of a bed of 1½ to 3-inch broken stone, 3 to 6 or 8 feet in depth. The sewage is applied intermittently as a spray or in thin sheets to the surface of the bed, trickles down through the stone and is collected by underdrains at the bottom. The filter is usually built with a concrete bottom and with stone or concrete walls to retain the broken stone. Application of the sewage is by spray nozzles or rotary distributors, which have been used on most recent installations. The rate of application for standard filters is usually about 300,000 gallons per day per acre per foot of depth, based on average flow. That is, for a bed 6 feet deep, the rate per day per acre would be 300,000 x 6, or 1,800,000 gallons. This rate of application has been exceeded in some recent installations.

High capacity filters, however, operate at very much higher rates—often from 10 million to 25 million gallons per acre per day. Some of these utilize recirculation of the effluent.

Only settled sewage, that is sewage that has been passed through a settling or Imhoff tank, should be applied to trickling filters. Raw sewage, from which the solids have not been removed, will clog the stone beds.

The stone particles are, of course, too large to strain out the suspended matter in the sewage. Purification is effected by the organic film which forms on the surface of the stone. The sewage trickles in thin sheets over the organic film. This film contains aerobic bacteria which oxidize and stabilize the organic matter in the sewage, and other micro-organisms whose function is not definitely known. There is a considerable reduction in bacteria, in organic content and in B.O.D. However, the effluent from a trickling filter, like any other sewage effluent, is dangerous and requires careful disposal.

(a) *Methods of Applying.*—The illustrations herewith show both of the usual methods of applying sewage to trickling filters.

(b) *Care of Nozzles and Orifices.*—All clogged spray nozzles or orifices in revolving distributors should be cleaned as soon as clogging is noticed. Clogging is liable to be due principally to match sticks or other small solids, or to grease. To reduce trouble from the first cause, place a fine screen in the discharge channel of the sedimentation tank or the inlet to the dosing tank; to prevent trouble from grease, keep the dosing tank free from accumulations and deposits.

(c) *The Dosing Tank.*—The dosing tank takes the flow from the Imhoff or settling tank, holds it temporarily, and then discharges it at a controlled rate through a siphon, to the nozzles or orifices onto the bed. The interior of the dosing tank used for spray nozzles has one or more sloping sides to insure that all portions of the area around each spray nozzle receives an equal dosage of the sewage. Thus, when the dosing tank is full and begins to discharge, there is a greater head and the nozzles spray over a wider area, but as the head becomes less in the dosing tank, the nozzles spray a less area. The tank is made smaller at the bottom therefore so that the smaller areas sprayed with the lesser heads will receive the same dosage per square foot. (See Fig. 14.)

A siphon controls the flow from the dosing tank. When the tank becomes empty, the siphon cuts off the flow to the nozzles, permitting the tank to fill again and repeat the cycle. Operation is controlled by air compressed under the bell of the siphon by the rising sewage.

Perhaps the most common difficulties in the operation of dosing tanks are due to air leaks in the control piping. This may result in the siphon discharging before the tank is filled, in which case only that portion of the filter nearest the nozzle is dosed. Or the tank may fail to fill, and a continuous small flow passes through it, too small to cause a spray from the nozzles.

Occasional cleaning of air and water lines is desirable, special precautions being taken with the connections of the air pipes to prevent leaks. Air leaks are difficult to locate, and in case of continued trouble from this source, it may be cheaper to replace all air piping with new lines.

Grease and other solids accumulate in dosing tanks and may cling to the sides, especially at the high water line. This material dislodges and may pass through the siphon and clog the nozzles. It should be removed regularly to prevent such accumulations.

Fig. 13. Trickling filter, showing distributor arms, inflow pipe and floor drainage system.

(d) *Pooling or Ponding.*—Pools or ponds sometimes form on the surface of the filter. This is usually due to organic growths or to retained organic matter from poorly settled sewage. Sometimes it is due to carelessness in dumping fine materials in one place when building the filter. When this is the cause, the fine material must be removed and replaced with suitable stone.

In many cases the trouble lies in the top layer of the stone, and forking or raking the stone to a depth of 8 to 12 inches or so is effective. Other methods include washing the surface of the bed with a heavy stream from a fire hose; taking the bed out of service for 24 to 48 hours, if this can be done without detriment to the quality of the effluent; flooding the bed for about the same period, if the bed is so constructed that it can be flooded; or by applying rather heavy dosage of chlorine to the sewage before it reaches the bed.

Application of 3 to 5 ppm. of chlorine has been found helpful; in some cases, dosages up to 10 ppm. have been used. Caustic soda has also given good results with dosage of about 10 ppm. When using chemicals, as chlorine, treatment may be given for 8-hour periods on alternate days.

(e) *Filter Flies.*—The larvae of the filter fly (Psychoda alternata) may cause clogging or impair the efficiency of the filter. The adults may be present in such numbers as to be a nuisance at the plant and at houses within a quarter or half mile of the plant.

The flies lay their eggs in the filter film; the incubation or development period depends on the temperature, but is about 9 days. The larvae can be drowned by flooding the filter for a 24-hour period at intervals of 9 or 10 days. Chlorination, as directed in the preceding article, using 3 to 5 ppm. of chlorine is reported to be effective, if application is made every 7 to 10 days.

Adult flies can be killed by using any of the commercial fly or insect sprays, or by burning with a blow torch, but these methods are possible only after the nuisance has been produced. Prevention is far better.

(f) *Underdrains and Pipes.*—In most plants there is an arrangement for inspecting the underdrain system; if this is not provided, an inspection of the flow from each of the underdrains is usually possible. The flow should be noted, and if clogging is indicated by reduced flow from any drain, this should be flushed out or cleaned with sewer rods. Underdrains should be flushed regularly, especially during first year or two of operation.

Also, in most plants using filter nozzles each line of distribution piping is provided with a plug or valve so that the line can be flushed out. Where such provision has not been made, the spray nozzle at the end of each line can be removed during a dosing period. This will usually give sufficient velocity through the line to flush it out.

(g) *High-Capacity Filters.*—The general directions outlined above apply also to high-capacity filters of the Biofilter, Aerofilter or Accelo-Filter types. In the Biofilter, a portion of the effluent from the filter is recirculated to the primary settling tank and, by dilution, lowers the B.O.D. of the raw sewage. The application to the filter surface is at a much higher rate—usually 10 to 13 million gallons per acre per day, and the B.O.D. load applied may be 2400 to 3200 pounds per acre foot. Uniformity of operation procedure and maintenance of adequate recirculation, which may be varied in some plants in accordance with flow and strength of sewage, seem to be important.

The aerofilter applies the sewage in a very fine spray, thus making most efficient use of every particle of stone in the filter at all times. The B.O.D. loading is about the same as the biofilter, but the rate of application to the filter is higher. Recirculation is utilized only at very low flow periods.

The Accelo-Filter utilizes recirculation to the distributor, with a B.O.D. loading about the same as the others and an application rate of 10 to 13 mgad.

Filter flies are not normally numerous at high capacity filter plants.

(h) *Winter Operation.*—In systems with spray nozzles, the pipes carrying the sewage to the nozzles may freeze. A small bleeder tap, or a partly opened valve may be used to keep the distributor lines empty between doses. Such a tap or valve should be set in a small manhole.

In revolving distributors, the sewage enters through the central column. In extreme cold weather this portion of the distributor should be wrapped with burlap, or otherwise protected to prevent freezing. Or a small tap may be placed to drain the column slowly if there is an appreciable interval between dosages.

(i) *Odors and Prevention.*—If the sewage is septic, spraying it into the air is effective in liberating the contained hydrogen sulphide gas, thereby causing odor. This occurs also, but not to the same extent, with the rotary type distributor.

Odors must be controlled by eliminating the causes before the sewage reaches the nozzles. Prechlorination is probably most effective and economical. This is described more fully in the section on chlorination.

(j) *Records of Operation.*—The operating record should show the units of the filter in service each day, the number of nozzles cleaned, the dates of cleaning the distributor mains and the underdrains, and similar detail data; the rate at which the filters were operated; and, in the case of biofilters, the amount of recirculation.

Methods of treatment and dates of measures taken for correction of ponding and for *phychoda* control, and for other unusual occurrences should be recorded in plant operation data.

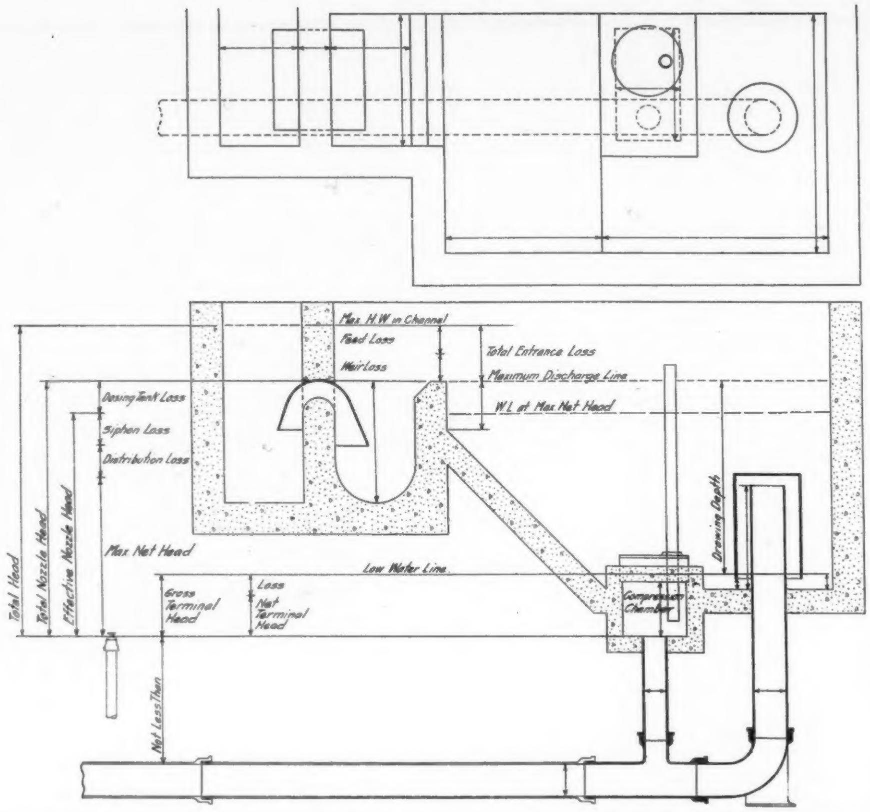


Fig. 14. Section and half plan of twin dosing tank for separate nozzle fields. Pacific Flush Tank Co.

Results of treatment are recorded by means of B.O.D. tests on the influent and effluent. Or, where B.O.D. tests are not made, results of methylene blue tests should be noted. Settleable solids in the filter effluent may be recorded by means of tests with Imhoff cones.

(k) *Secondary Settling.*—From time to time, but most generally in the spring and fall, standard rate trickling filters "unload." High-capacity filters unload continuously. The material accumulated in the interstices of the bed slough off and are washed out by the sewage. It is customary to provide a secondary settling tank for the effluent from the trickling filter bed; the usual period of detention is 1 to 1½ hours for standard-rate and 2 hours for high-capacity filters. Operation of this secondary settling tank does not differ materially from the operation of primary settling tanks.

Loading on Trickling Filters.—To check the loading on a trickling filter, determine the B.O.D. of the sewage applied to the filter, in parts per million. The flow in million gallons per day x the B.O.D. in ppm. of the sewage applied to the filter x 8.33 gives the pounds in 5-day B.O.D. applied per day. Divide this by the area of the filter in acres. This gives the loading per acre. A loading of 1800 to 2200 pounds per acre of surface area 6 feet deep is about normal for a standard rate filter. For a high capacity filter, a loading of 1.5 to 2.0 pounds per cubic yard of stone or 2440 to 3200 pounds per acre-foot is usual, as compared to about 400 pounds per acre-foot for the standard rate filter.

X.—Contact Beds and Sand Filters

Contact beds, not now used in municipal plants, are composed of broken stone of about the same size and character as is used in trickling filters; but the stone is contained in a tight tank. Instead of trickling over the stone, as with the trickling filter, the sewage is held in contact with the stone for one or more hours, hence the name contact beds. The same type of organic film forms on the stone as in the case of trickling filters, and the same oxidizing action takes place. The rate of operation is lower than in trickling filters, being usually about 125,000 gallons per day per acre per foot of depth; average depth is around 3 feet.

The cycle of operation is approximately as follows: illing the bed, the time depending upon the rate of flow of the sewage; standing full, from 1 hour or even less to 2 or 3 hours; emptying, 30 to 45 minutes, but depending upon the size and design of the bed; resting, 3 or 4 hours.

The resting period is most important, as it is during this time that the bacteria in the film on the stones reduce the organic material that has been deposited.

Control of operation is usually by airlocks and siphons. These fill the bed, divert the flow to another bed when the first bed is filled, regulate the period of standing empty; and, when the other beds have been dosed in rotation, once more fill the first bed.

(a) *Operation Factors.*—The surface of the beds should be kept free from growths; the dosing apparatus should be inspected and timed daily to see that it is working properly and in order to determine the cycle of operation. Air leaks or clogged lines will interfere with the proper operation of the controls. Pipes should be kept clean, and joints and piping must be tight.

When new, contact beds have voids of about 40% or 45% of the capacity of the tank, and the bed will hold a volume of sewage equal to 40% or 45% of the tank capacity. With use, this capacity decreases, and after a few years may be only half or even less of its original capacity. This is due to the solids that are deposited by the sewage in the bed.

When the capacity is considerably reduced, the stone can be washed and replaced, or the old stone can be removed and new stone put into the bed. In order that the capacity may be known, the time required to fill, and the rate of flow of sewage must be known. The capacity can then be computed.

Operation records should show the number of beds in service, the total number of fillings per day for each bed, and the quality of the bed effluent as determined by the B.O.D. or methylene blue test. Such tests should be performed once or twice a week, in the smaller plants, and daily in larger installations.

A sand filter consists of a bed of about 30 inches of sand, with underdrains, and with provision for applying the sewage to the surface.

The mechanical straining action of the sand removes some of the impurities from the sewage; and additional treatment results from an organic film on the surface of the sand grains. This organic film is of the same nature as that which forms on the surface of the stone in a trickling filter, and it operates in the same manner.

The rate of operation of a sand filter is about 75,000 to 100,000 gallons per acre per day, without regard to depth. Results of treatment are better than that obtained from either trickling filters or contact beds. But the large area of filters required for a city of even moderate size, and the possibility of odors arising from the beds make the use of this method of treatment unsuited for more than a few small communities.

(a) *Operation of Sand Filters.*—Sewage is applied intermittently to the beds. An acre contains 43,560 square feet. The rate of application depends on the kind of sewage, as raw or settled. If the rate of operation is 87,000 gallons per day, the rate per square foot is 2 gallons per day. A cubic foot of water contains 7.5 gallons. Therefore, for a rate of 87,000 gallons per acre per day, the depth of sewage to be applied daily is $2 \div 7.5$, or 0.22 ft., or a little more than 2½ inches. This is applied at one time, and no more sewage applied for 24 hours. In some cases, a greater depth than 2½ inches is applied, with correspondingly longer rest periods; and some plants apply sewage continuously for 24 hours and then allow the bed to rest for several days.

The beds should be taken out of service at intervals and rested, allowed to dry and the surface raked or scraped clean to remove the surface mat that sometimes forms. The sand should not be plowed, harrowed or spaded over, as this tends to place the already clogged sand beneath the surface. The bed should be raked lightly as needed until there is some indication that the top surface is becoming clogged, when a thin layer should be removed—¼ to ½ inch.

The surface of the beds must be kept level, so that all portions will receive the same dosage, and vegetation should not be allowed to grow.

About once a year, the beds should be scraped thoroughly, and clean sand added to bring them to their original depth.

Winter Operation of Sand Beds.—For winter use, the beds often are ridged, that is, the sand is raked up into ridges about 1 foot high and 2 feet apart; or the sand can be raked into piles 6 to 12 inches high and about 2 or 3 feet apart each way. With the arrival of cold weather, the beds are filled to the tops of the ridges and ice is allowed to form. This ice is supported on the ridges or piles and forms a protecting cover which permits operation of the bed. Care should be taken that the ridges are so placed that all parts of the bed are accessible to the sewage.

As soon as danger from ice is past, the bed should be cleaned and leveled.

Operation Records.—Records should show the number of beds in service, with the rate of application; the number of beds cleaned and the amount of material removed; and the B.O.D. or the putrescibility of the sand bed effluent by the methylene blue test.

XI.—Chemical Treatment

Certain chemicals are added to sewage to aid in the removal of suspended matter. These chemicals form a flocculent and gelatinous precipitate, which not only entraps the finer particles suspended in the sewage, but also expedites settling.

In a well-designed and well operated plant, the B.O.D. can be reduced about 75%, and the settling tank effluent can be made clear by the use of chemicals.

(a) *Chemicals Used.*—The iron salts (Ferrisul, ferrous sulphate, chlorinated copperas and ferric chloride) and aluminum sulphate are employed in the chemical treatment of sewage as the coagulating agents; and lime to supply alkalinity or other factors required.

The choice between the coagulating agents mentioned depends upon the size of the plant, the character of the sewage and the cost of chemicals, which vary somewhat from place to place. Tests are desirable in advance of selection. In large plants ferric chloride often has advantages, whereas in the smaller plants chemicals that are easy to store, handle and apply, such as ferrisul or aluminum sulfate, are desirable.

(1) *Ferrisul and Ferrifloc.*—These are the trade names for ferric sulphates that are prepared in a granular form for easy handling and feeding. They form a floc over a wide pH range and are therefore unaffected by such changes as ordinarily occur in sewage. Enough alkaline materials are generally present in the sewage to react with the ferric salts; if not, lime must be added.

They are ordinarily fed dry to a dissolving pot, but may be made into a batch solution and fed in this form.

(2) *Aluminum sulphate* has the formula $Al_2 = (SO_4)_3$, 18 H_2O. Coagulation is best between pH values of 6.5 to 8.5. Aluminum sulphate is ordinarily supplied in a powdered or ground form for feeding dry; but may also be fed as a solution.

(3) *Ferrous Sulphate.*—Frequently called copperas, this chemical should not be confused with copper sulphate. It has the formula Fe SO_4, 7 H_2O. It is available in the lump form or as granular sugar of iron.

(4) *Chlorinated Copperas.* — Chlorinated copperas is made at the point of use by adding chlorine to a ferrous sulphate solution. The reaction between the chlorine and the copperas results in ferric sulphate and ferric chloride.

(5) *Ferric Chloride.*—Ferric chloride reacts with lime to form an insoluble ferric hydroxide. Coagulation and floc formation take place over a considerable pH range. Ferric chloride is usually fed as a solution.

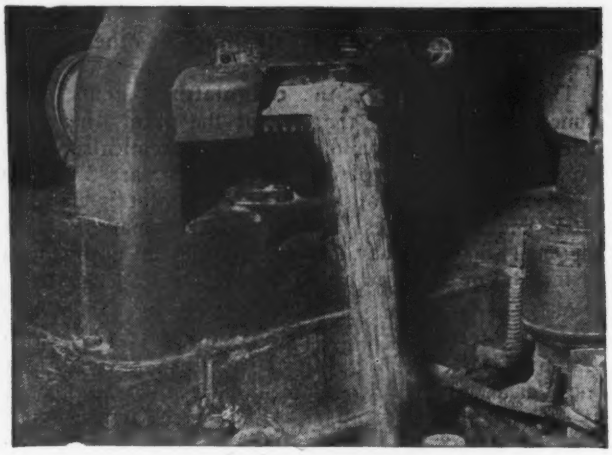
(b) *Applying the Chemicals.*—The chemicals are applied dry, or in solution, according to their characteristics. As a rule it is simpler to use dry feed than to prepare solutions; and some chemicals do not go into solution readily. Also, it is simpler to use one chemical than to use two, especially when the relative dosages have to be adjusted to each other. These statements apply particularly to the small plant where the skilled labor for mixing and for careful control of two or more feeding machines is not always available.

Some chemicals are corrosive and require feeders that are lined with rubber or that are made of corrosion resisting metals. Information on this can be obtained from the manufacturer of the chemical, or, usually from the maker of feeding equipment.

(c) *Mixing the Chemicals.*—Thorough and complete mixing of the chemical with the sewage is essential for good results, and also saves chemical. The mechanical mixer or flocculating unit, or some similar device is practically necessary. Some chemicals require more violent mixing than others, and some sewages also appear to require more or less violent mixing than others.

Temporary devices or improvised mixers may be used for preliminary trials to determine the results of chemical treatment, but proper mixing devices should be installed for permanent use, even if treatment is to be used only for two or three months in the summer, as the better results obtained will justify the cost.

(d) *Dosages of Chemicals.*—The dosage required depends upon the results desired. In most plants an



"International" dry feeder feeding "Ferri Floc" (manufactured by Tennessee Corporation) at Atlanta, Ga. Dose: 1 gpg. Dust shield has been removed.

insufficient dosage is employed to give the fine results that chemical treatment is capable of producing. Sewages vary so greatly in strength that no set rule can be laid down. Laboratory jar tests are useful in estimating probable required amounts of chemical. It is suggested that with average sewages, the minimum trial dosage be 80 ppm. and that trials also be run at 100, 120 and 140 ppm. The reason for this is that tests are usually made in the forenoon or early afternoon when sewage is strongest and most difficult to coagulate, where from 5 P. M. to 9 A. M. a much smaller amount of chemical can be used.

A smaller dose—50 or 60 ppm.—may produce an effluent that is vastly better than that obtained without chemical treatment; but an adequate amount of chemical will, in most cases, produce a clear and sparkling effluent, almost equivalent in appearance to that from a sand filter. Such smaller dosages will often produce excellent results with the weaker night sewages. However, a must larger dissolved B.O.D. exists in a chemically coagulated tank effluent than if ordinary sedimentation and supplementary oxidation are employed.

(e) *Results of Chemical Treatment.*—With adequate amounts of chemical in a properly designed and operated plant, turbidity can be entirely removed in most cases during the entire 24 hours. The reduction in B.O.D. will average about 75%; suspended solids are almost entirely removed; there is some reduction of dissolved solids and colloidal matter.

(f) *Essentials in Chemical Treatment.*—First in importance is the selection of the proper chemical. Experience indicates that no one chemical is best for all sewages. Before finally selecting a chemical, several should be tried, each for an adequate period, to show its real worth.

Proper feeding equipment, proper mixing equipment, and a fairly adequate settling period are necessary for good results, even after the most suitable chemical has been selected. A reasonable amount of laboratory equipment and a place in which to do laboratory work are also necessary.

Experience emphasizes that a greater sludge digestion capacity is required with chemical precipitation than for plain sedimentation. It is believed that in heated tanks at least 3 cu. ft. per capita should be provided, and much more in unheated tanks. Gas production is generally considerably greater per capita. A minimum settling period of 2 hours appears necessary, and more is probably desirable. Darby suggests the overflow rate should be 800 to 1000 gals. per sq. ft. of tank area per 24 hours.

XII.—Disinfection of Sewage

Chlorination of sewage is employed for a number of purposes: 1. To reduce the bacterial content of the plant effluent and thereby make it less of a nuisance and danger to bathing beaches, shellfish beds, etc.; 2. To control or prevent odors; 3. To aid in coagulation when ferrous sulphate or copperas is used as a coagulant; and, 4. To reduce the B.O.D. of the sewage.

(a) *Bacterial Reduction.*—While it is not possible to kill all the bacteria in sewage by chlorination, the number can be greatly reduced. This does not make water into which chlorinated sewage has been discharged safe to drink, but it does lighten the load on water purification processes.

For raw or untreated sewage, a fair application is about 20 ppm.; for settled sewage, 10 to 12 ppm.; and for the effluent from a trickling or sand filter, about 5 or 6 ppm.

The required amount of chlorine is best determined by the orthotolidine test which measures the amount of chlorine remaining after a contact period, of about 15 minutes.

Strength of sewage varies considerably throughout the day, being strongest, as a rule, after the middle of the forenoon. Dosages of chlorine should be adjusted for this period; an adjustment of the chlorine application can be made for the reduced and weaker night flows in many cases.

(b) *Odor Control.*—As sewage decomposes, odors occur. The most common and important agent causing odors is hydrogen sulphide. Chlorine is used both to prevent its formation and to react with it after it has been formed. Control is more effective, as much less chlorine is required for prevention than for neutralization.

The most common method of prevention is to apply the chlorine in the main sewer as far as possible above the treatment plant. Chlorine acts on those organisms in the sewage which decompose the sulphur compounds, and prevents the formation of the hydrogen sulphide. From 3 to 30 ppm. of chlorine may be required; generally 8 to 10 ppm. will effect a marked reduction in odors. In some places odors are noticeable only during the evening. Under such conditions, chlorination may be needed for only a portion of the day.

After the hydrogen sulfide is released, chlorine will combine with it to reduce or prevent odors, but the amount of chlorine required is considerable, and such procedure is very rarely if ever economical.

Odors from trickling filters have been reduced in some cases by 3 to 6 ppm. of chlorine.

(c) *B.O.D. Reduction.*—When sufficient chlorine is applied to sewage so that there is a residual of 0.2 to 0.5 ppm., there is a reduction in the 5-day B.O.D. This reduction depends to a considerable extent upon the characteristics of the sewage, but is estimated at from 10 to 25 per cent. That is, if a sample of sewage shows a B.O.D. of 85, chlorination may be expected to effect a reduction to about 70. Each part per million of chlorine absorbed will reduce about 2 ppm. of oxygen demand. Apparently this reduction of B.O.D. by chlorination is permanent.

(d) *Coagulation.*—Chlorine is used with ferrous sulphate (copperas) in chemical treatment, to form chlorinated copperas, an effective coagulant. It is also used in connection with ferrous sulphate and lime to furnish the oxygen necessary to change the ferrous hydroxide to ferric hydroxide, the desired coagulant.

(e) *How Chlorine is Used.*—Chlorine is employed primarily in the form of liquid chlorine, Cl.; and also in the smaller plants, as calcium hypochlorite. Liquid

chlorine is 100% available chlorine. Actually it is a gas, but under pressure it becomes a liquid in which form it is shipped in steel cylinders. The pressure varies with the temperature from 40 to about 150 pounds, being greatest at high temperatures. At 70°F., it is about 85 pounds per sq. in. The cylinders used in small plants contain 100 or 150 pounds of chlorine, but larger containers are available.

Calcium hypochlorite solutions are prepared from commercial bleach (also called bleaching powder, chloride of lime and chlorinated lime, which is made by saturating quicklime with chlorine). Two types of calcium hypochlorite are available: The standard bleaching powder contains 25% to 35% of available chlorine and loses strength (that is, available chlorine) quite quickly when exposed to air. The other form available is more a stable form with a much greater chlorine content. H.T.H. and Perchloron contain about 70% available chlorine.

(f) *Applying Liquid Chlorine.*—Liquid chlorine is applied by means of a chlorinator, the function of which is to take the liquid chlorine from the cylinder, measure it, and feed it into the sewage at the desired rate. Application may be in either of two ways. As a gas, or mixed with water to form a solution, which is then added to the sewage.

The solution feed apparatus is used almost exclusively in sewage treatment. A supply of water under some pressure must be available for operating the machine, the amount of water depending upon the size of the chlorinator and the amount of chlorine fed.

(g) *Operation of a Chlorinator.*—For proper operation, the room in which the chlorinator is kept should be over 50° F. Warm gas entering a colder chlorinator will condense and may cause clogging. Therefore, the chlorinator should not be placed on an outside wall, but should be in a warmer place than the cylinder or the pipe connecting the cylinder and the chlorinator. A radiator, a small stove, or an electric heater may be used. The chlorinator building should be insulated or well protected. When cold is not too intense, an electric light left burning, or even a lighted lantern may furnish the required heat.

Chlorine cylinders should be kept on scales and the weight read each day as a check against the amount of chlorine used; or in the case of very small plants, the scales may be read weekly.

The maximum drawoff or discharge from 100 and 150 pound cylinders at 70° F. is approximately 35 pounds per 24 hours. Due to the change from a liquid to a gas, an excessive drop in temperature will occur and if more than 35 pounds are used daily, 2 or more cylinders should be attached.

A reserve supply of chlorine should be kept on hand; also a supply of duplicate parts, including valves, gaskets, etc. But the operator should not attempt major repairs. Whenever possible an entire duplicate chlorinator should be kept on hand for possible emergencies. Ask the manufacturer of your chlorinator for full directions for starting and stopping, and for other details regarding it.

Chlorine leaks are, of course, dangerous since the gas is irritant to the lungs and causes violent coughing. A concentration of 1 part of chlorine in 100,000 can be noticed; 1 part to 50,000 parts of air causes inconvenience; *and 1 part in 1000 of air after 5 minutes exposure produces death.* Leaks can be located by means of an open bottle of ammonia. Valves, connections and other places that may permit chlorine to escape are tested with the ammonia bottle. White fumes

of ammonium chloride are formed when chlorine combines with ammonia. Special gas masks are desirable for use in case of leaks. Chlorine being heavier than air, ventilation at or near the floor level is desirable.

Metal parts on the chlorinator, or other metal surfaces, may become corroded. To prevent this, these may be painted with a thin coating of gasoline and vaseline. The gasoline evaporates and leaves a light coat of vaseline which is sufficient protection.

(h) *Chlorination with Bleaching Powder.*—Since effective chlorination cannot be obtained by feeding the dry powder, a solution must be made and fed into the sewage. There are several excellent feeders for this purpose. Because conditions of use for hypochlorite solutions differ so materially, the advice of the State Sanitary Engineer should be sought regarding their installation.

It is easier to feed a weak solution using larger quantities, than to apply small amounts of a concentrated solution. To make a solution containing ½% of available chlorine, using 100 gallons of water, which weighs 834 pounds: Chlorine required is ½% of 834 = 4.17 pounds. If the bleach has a chlorine content of 25%, which is about the average, 4.17 ÷ 0.25 = 16.68 pounds of bleach will be needed for 100 gallons of solution.

When H.T.H. or Perchloron are used, with a 70% available chlorine strength, 4.17 ÷ 0.7 = 6 pounds of chemical will be needed per 100 gallons of water.

Hypochlorite solution may be purchased ready for use; but it is usually cheaper to make it up. To do this, a mixing tank, with motor driven paddles is desirable. The bleach is added to the water, or preferably made into a paste and added. After mixing 15 to 30 minutes, the solution should be allowed to stand for an hour to permit the particles of lime to settle.

Solutions lose strength on standing even in dark, cool places, and therefore should be used promptly.

(i) *Computing Dosages.*—When using liquid chlorine, the desired dosage in parts per million *times* the number of million gallons per day *times* 8.33 is the number of pounds of chlorine to be fed daily. For instance, to treat 2 mgd. with 6 ppm. of chlorine, 6 x 2 x 8.33 = 100 pounds per day.

If it is desired to vary the amount of chlorine hourly, the number of gallons per hour *times* the dosage in parts per million *times* 8.33 indicates the number of pounds per hour. For example, with a dosage of 8 ppm., and a flow of 300,000 gallons per hour, there will be required per hour, 8 x 0.3 x 8.33 = 20 pounds.

Most chlorinator scales read in pounds per 24 hours. For the proper setting, multiply the hourly rate by 24. In the above case, the rate in pounds per 24 hours would be 20 x 24 = 480 pounds.

(j) *Dosages with Bleach.*—To chlorinate 70,000 gallons of sewage per day using a dosage of 5 ppm., with HTH or Perchloron: 5 x .07 x 8.33 = 2.9 pounds of chlorine (70,000 gallons = .07 mg.). HTH or Perchloron has 70% available chlorine, and the amount required is 2.9 ÷ 0.7 = 4.2 pounds.

(k) *Records of Operation.*—The records covering the application of chlorine should show (1) the volume of sewage chlorinated daily; (2) the rate of application of the chlorine; (3) the residual chlorine present which, if taken daily should be at the same hour every day; (4) the weight each day, at the same hour, of the chlorine tanks; and (5), new cylinders placed on the scales and their weight.

XIII.—Sludge Digestion Tanks

The disposal of sludge that is deposited in the bottom of sedimentation tanks is one of the serious problems in the operation of a sewage treatment plant. This material is highly decomposable and offensive. Generally the best method of treatment is by digestion. In this, the sludge is stored in deep tanks for 30 to 50 days or longer, during which time the organic matter is digested and converted into more stable forms. After this digestion process, the sludge can be dried on sand beds without nuisance. Digestion tank equipment is made by Dorr, Pacific Flush Tank, Link-Belt and Infilco.

(a) *Moisture Content.*—The solid materials in raw sludge as drawn from settling tanks does not ordinarily exceed 4% or 5%, the remainder being water; and in very thin sludge, there may be only 1% or 2% of solids. Where the solid content is only 1%, there are 99 volumes of water for each one volume of solid material; where it is 2%, there are 49 volumes of water for each; and where it is 4%, there are 24 volumes of water. Thus a sludge with 1% of solids is, for the same volume of solids, about four times as great in volume as a sludge that has 4% of solids.

(b) *Amount of Sludge.*—The moisture content has such a bearing on the volume of sludge that it is difficult to make a statement as to the volume of sludge to be expected. The only basis on which to make a comparison is that of the amount of dry solids, which is secured by evaporating the sludge to a bone-dry condition. The usual sewage treatment plant will remove from 100 to 300 pounds of dry solids per 1000 population or 1/10 to 2/10 pounds per person per day. The actual amount of sludge varies from 2500 to 10,000 or more gallons per million gallons of sewage.

(c) *Sludge Digestion Tanks.*—Tanks for sludge digestion are normally built of concrete. Some are provided with stirring equipment; others rely on natural changes for whatever mixing is necessary, as from the addition of fresh sludge and drawing out the digested sludge.

Sludge digests best at a temperature of 80° to 95° F. Sewage is much cooler than this—usually varying, during the year, from 45° F. to 70° F. Therefore in most tanks it is desirable and economical to heat the sludge, since digestion is more rapid and a smaller tank can be used—2 to 3 cu. ft. per person is probably enough for a heated tank, but at least 4 cu. ft. per person is necessary for an unheated one. (Except in warm climates.) In both cases, more space may be required if secondary treatment is provided. This heating is usually accomplished by means of hot water pipes placed around the inside of the tank, as shown in Fig. 15 and the water is heated by burning the gas that is formed during the digestion of the sludge. This gas, which is largely methane—about 65%—has a heat value of around 650 b.t.u. per cubic foot or about the same as ordinary cooking gas. About 1 cu. ft. per person per day is produced on an average, but this may be more or less.

(d) *The Dorr Digester.*—The Dorr 2-stage or multidigestion system is shown in Fig. 17. In this method there are two tanks. The greater part of the work of digestion is accomplished in the primary tank, which is heated. This is equipped with mixers. Final digestion takes place in the secondary digester, which is equipped with a gas holder.

The PFT Floating Cover.—Fig. 15 shows a digestion tank equipped with a Pacific Flush Tank Co. floating cover. The sludge enters the tank through the sludge inlet. No stirring devices are provided. The cover floats on the surface of the sludge, and the gas is collected in the gas chamber at the top.

Sludge is drawn off from the bottom. The principal parts of the digester are indicated in the drawing. Pacific Flush Tank Co. also makes a 2-stage digester, Fig. 18.

(e) *Operation Details.* — Sludge should be added on a regular schedule and in as small increments as possible, since a heavy load of fresh solids may interfere with digestion. Sludge should be completely removed from the settling tanks, but excess sewage should not be drawn since too great a volume of material may retard digestion. It is not generally possible to store or hold sludge in the settling tanks; the digestion tanks must be capable of taking all the sludge that is produced every day.

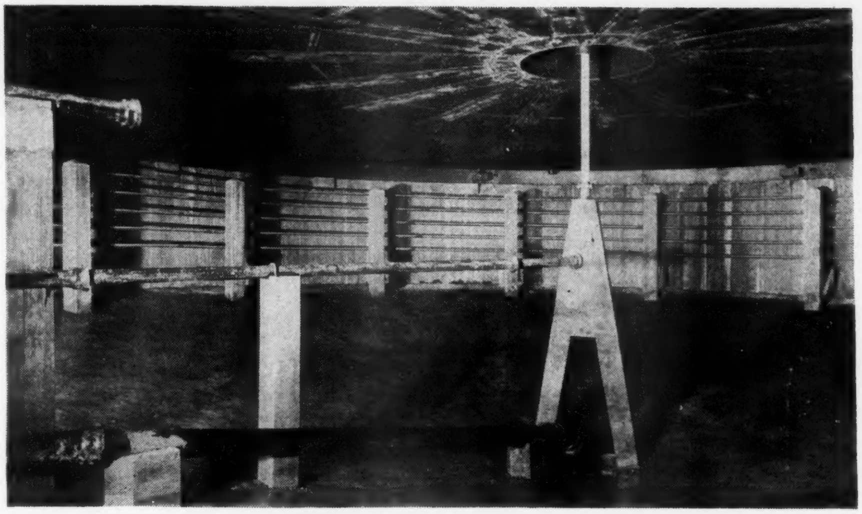


Fig. 15. Interior of PFT 75 ft. floating-cover digester at Greenville, S. C.

Where digesters are equipped with mixers they should be operated in accordance with the manufacturer's instructions. Where mechanical mixers are not provided but there are facilities for recirculating by pumping, some operators prefer to use these facilities for promoting digestion, breaking down scum, mixing lime with the sludge for pH value adjustment, etc. Where no facilities for mixing or recirculating sludge are provided, the operator must rely upon natural mixing of the raw sludge and digested sludge in the digestion unit.

The hot water pumped into the heating coils of the tank is generally maintained at a temperature of about 120° F. to 130° F. A temperature much above 140° or 150° F. will tend to take the sludge on the outside of the pipes and cause loss of heat conductivity. The contents of the tank are kept at from 80° F. to 95° F. Thermometers record the temperature of hot water and of the cooler return water; also of the temperature of the digesting sludge.

Sludge is removed when it is fully digested, or sometimes when the tanks are full and sludge drying beds are empty. The former is desirable; the latter may be necessary. Most digesters are provided with devices for sampling the sludge, so that only fully-digested sludge need ordinarily be drawn. Well digested sludge is usually granular in appearance, without any pronounced odor, and dark or nearly black in color. Too much sludge should not be romoved at one time. To do this may rob the tank of the "ripe" sludge and leave an insufficient amount of this to mix with the fresh sludge added every day. Ordinarily, when sludge is drawn, the sludge drying bed unit is filled to capacity. This is necessary because the number of drying beds available is usually limited and each must be worked nearly to capacity. When drawing the sludge, the operator should watch the sludge and cease drawing it whenever any change in appearance is noted that indicates improperly digested sludge. Generally not over 10% of the capacity of the digester should be drawn at one time.

. Hardinge digester, 50 ft. diameter by 20 ft. deep, center column type, with sludge stirring, scum breaking and gas collection equipment.

Frequent pH tests of the sludge should be made. This is not easy with ordinary pH apparatus, and electrical pH apparatus is recommended. If the color test method is used, the sludge may be centrifuged, which is not always satisfactory; filtered, which gives somewhat high results; or diluted with distilled water, allowed to stand and the pH taken on a clear portion. Sludge digestion proceeds most favorably at pH values of 7.0 to 7.6—preferably above 7.2, but many plants report good results with pH readings of 6.8. Check the pH with the alkalinity of the supernatant or the sludge, which may run from 1500 to 3500 ppm. and affords an excellent check on operation. The Editor would be glad to have readers send in reports of supernatant alkalinities, with comments on operation results.

If the pH value is below 7.0, it is usually desirable to try to raise it. This is most frequently done by adding lime to the sludge as it enters the digester. It is almost impossible to determine, except on the basis of past experience, how much lime should be added. The alkalinity of the supernatant is a help on this. A start might be made using ¼ to ½ pound per cubic foot of sludge, and more added if the pH value or alkalinity does not rise appreciably in a few days. This can be added at the sludge pump, or in the recirculation pump if there is one, as recirculation is very helpful in mixing.

Activated carbon has been effective in some plants in raising the pH and in aiding digestion. If used, it should be added in the form of a slurry, mixed with water to form a paste. It may be added at the rate of 15 to 25 pounds per million gallons of sewage; if each million gallons of sewage produces 10,000 gallons of sludge, and it is desired to dose the entire digester,

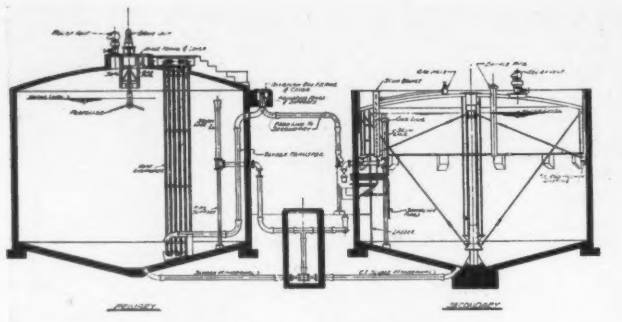


Fig. 17. The Dorr multdigestion system.

add at the rate of 15 pounds per 10,000 gallons of sludge and note the effect, delaying adding more for several days.

In many plants, the first year of operation of a digestion tank is a troublesome one. The operator should secure detailed directions from the designing engineer or manufacturer of the equipment installed in the digester, and should follow these instructions, calling for further help as needed.

(f) *Operating Difficulties.*—Foaming may be due to acid sludge, to the addition of too much raw sludge at one time, to industrial wastes (as creamery, slaughterhouse, etc.), to too rapid digestion (as may occur in unheated tanks with the advent of hot weather), and to unknown other reasons. A frothy, objectionable material rises to the top of the tank and may even overflow, filling pipes and gas traps. If possible to dispose of it otherwise, do not add raw sludge for several days, and then only in small amounts. If the sludge is acid, try to bring it above the neutral point by adding lime or other material. Draw some sludge to reduce the level in the tank, but not too much, as this may rob the tank of the ripe sludge needed for digestion. If the trouble appears to be due to industrial wastes, try to correct these by pretreatment at the industry or at the treatment plant. If foaming is due to cold conditions in the winter, it may be preferable to empty the tank, store the sludge in a lagoon, and start using the tank again when the weather is warm.

In areas where the water contains considerable mineral matter in the form of sulphates, decomposition of these may take place in the digester with the production of hydrogen sulphide. If the tank is a closed one, and the gas is burned, there will be no odor; but the resulting acid may corrode meters, flame traps and perhaps piping. This is prevented by neutralizing the H_2S by passing the gas through iron oxide or other scrubbers; or by maintaining the gas at a high enough temperature to eliminate moisture in it, thus preventing the formation of the acid which is the corroding agent. It is well to consult with the manufacturer of the digester equipment.

(g) *Utilizing the Gas.*—The gas from digesters is commonly used for heating the water used to heat the sludge in the digester, and also for other purposes, as in the plant laboratory, for heating the plant buildings, and even for operating gas engines to drive pumps, when pumping is needed. As already stated, this gas is explosive and equipment for handling it and utilizing it should be furnished and installed only by a manufacturer specializing in this work, and not by plumbers; nor should it be homemade. For safety in sewage plants, see PUBLIC WORKS, Aug., 1938.

(h) *Supernatant Liquor.*—The overflow from the digestion tank, or *supernatant,* frequently offers a problem in disposal, since both its solids content and its BOD are very high. It is rather common practice to run or pump this back into the inlet of the sedimentation tank. In some plants this method of disposal is satisfactory; in others it appears to affect adversely the quality of the effluent. Probably the strength of the supernatant, the capacity of the digester and the characteristics of the sewage are factors.

In plants using chemical coagulation, the supernatant if returned to the settling tanks often interferes with coagulation and usually increases the amount of chemical required to form a satisfactory floc. In plants employing either plain settling or chemical coagulation, interference by the supernatant can be reduced by returning it at periods of light load, as at night, but other methods of its disposal should be considered if it causes trouble.

The supernatant amounts, in volume, roughly to the sludge pumped from the settling tank less that drawn onto the drying beds. It may average around 15,000 gallons per million gallons of sewage, but may vary greatly from plant to plant. Some attempts have been made to treat it on sand beds, as on sludge drying beds; it can be coagulated by the addition of about 250 ppm. of aluminum sulphate followed by a short period of settling—about 15 minutes. There is no established satisfactory method of disposal. If the supernatant appears to interfere with proper operation of the settling tank, treatment on sand beds may be tried with the advice of your state sanitary engineer. If the supernatant appears to be of unusually bad quality, ask for advice from the engineer or the manufacturer of the digester apparatus, as the difficulty may lie in faulty operation of the digester.

(i) *Operating Records.*—If sludge is pumped from the settling tanks to the digestion tanks a record of the hours of pumping and of the pump capacity should be

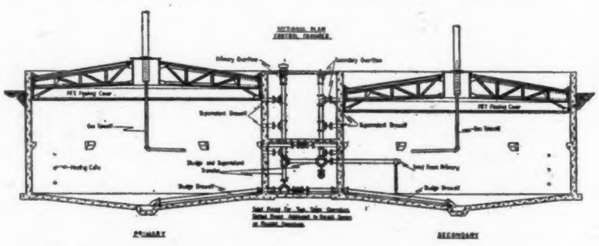


Fig. 18. Section of P.F.T. two-stage digester.

kept; it is very desirable to know how much sludge, in gallons or cubic feet, is added to the digester daily. The temperature of the sludge in the digesters should be recorded daily, or at least weekly; also the pH value of the sludge. The dates on which sludge is drawn should be recorded, and also the amount of sludge drawn, which can be determined approximately by the area of the sludge drying bed and the depth of the sludge on it. Frequently tests should be run to show the per cent of dry solids in the sludge as removed from the digester; other desirable information includes total solids and volatile solids in the digested sludge and the BOD of the supernatant. A record of the daily gas production from the digester should be made from the gas meter; also of water temperatures in the heating water.

Scott suggests the following method of computing the sludge pumped: measure the stroke of the pump, the diameter and the revolutions per minute; or shut off the flow into a settling tank, and measure the drop-down with 5 or 10 minutes pumping.

XIV.—The Disposal of Sludge

The sludge that is drawn from a sludge digestion tank or from the sludge compartment of an Imhoff

tank contains only a small percentage of solids—usually from 4% to 10%. The excess water must be removed. This is normally done on a sand bed, preferably covered with glass, or by means of special filters.

If the moisture content of the sludge can be reduced to 65% or 75% the sludge can be used as a fertilizer for parks, grass plots, farms, etc., or it can be piled up in heaps, or burned in an incinerator. It should be noted that sludge with 5% solids and 95% water is six times as bulky for the same volume of solids as sludge containing 30% solids and 70% moisture. [See sec. xiii, par. a.]

After it has been properly digested, sludge has little, if any, disagreeable odor and when properly dried or dewatered thereafter is unobjectionable. The removal of the excess water is necessary to facilitate final disposal.

(a) *Sludge Beds.*—A sludge drying bed consists of a layer of about 6 to 18 inches of sand, supported on 6 to 12 inches of graded gravel, under which are placed open joint drains. The water drains out of the sludge, and evaporates from it also—both actions being important. That part of the moisture which drains out passes down through the sand and gravel and into the underdrains which may discharge after chlorination into the outlet sewer from the plant; or into a pump sump from which it is returned to the sedimentation tank. The latter procedure is preferable.

Sludge drying beds may be either open or covered. Structures similar to greenhouses are generally used for covering the beds. The open or uncovered beds should generally provide 1 square foot of area for each person served by the plant. That is, for 10,000 persons contributing to the sewers there should be at least 10,000 square feet. Covered beds need be only one-half as large, that is, one-half square foot per capita. The covered beds are more effective because they keep off rain and also the temperatures inside of them are normally higher, resulting in greater evaporation. Ventilators should normally be kept open to aid in ventilation.

(b) *Depth of Drawing.*—The depth to which wet sludge should be placed on the beds depends upon the condition or quality of the sludge primarily. The average depth in usual practice is 8 to 12 inches of wet sludge. With well digested, quick-drying sludge, greater depth is permissible. There is, in most plants, a critical depth at which best drying is accomplished, and the operator should learn this as soon as possible. If a 10-in. drawing will dry in 10 days, and a 12-in. drawing in 14 days, the former is best.

A well digested sludge is perhaps the most important item in sludge bed operation, so that control of digestion tank operation affects materially sludge bed operation.

(c) *Care of Beds.*—After each layer of dried sludge has been removed, the bed should be raked and leveled. Some beds slope from the sludge discharge pipe to the far end, frequently at about 6 inches in 100 ft. However, the amount of slope that is desirable varies with the character of the sludge. Imhoff tank sludge is often thicker than sludge from a digestion tank. For the latter a practically level bed is best.

Sludge should never be discharged on a bed containing dry or partially dried sludge. Such material should be removed before another application of sludge.

When plenty of drying bed space is available, the sludge may be left until it is quite dry. In most plants excess area is not available and the sludge can be, and perhaps must be, removed as soon as it is dry enough to handle with a fork. It is preferable to remove the sludge at least a day or two before it is planned to apply more, to give the surface of the sand time to dry. Drying of sludge can be expedited by the use of chemicals, (see "f" below).

d) *Removing Sludge From Beds.*—A fork with 6 or more tines is generally used for removing the dried sludge from the surface of the beds. As little as possible of the sand should be removed with the sludge, but some will always stick to the sludge, so that there is a loss of sand with each layer of sludge removed. This requires eventual replacement of the sand. When the sand layer is reduced to 3 or 4 inches in thickness, more sand should be added. Occasionally the top layer of sand becomes clogged and interferes with drainage. When it is noted that a bed dries unusually slowly, the sand should be examined and if it appears to be

clogged with organic matter, the top 2 or 3 inches should be removed and replaced with clean coarse sand.

Beds are provided with overhead rails or other devices for handling the sludge. On small beds, after the sludge near the door has been removed, a runway of planks can be placed on the sand and a light truck backed in on the bed. Sludge can then be loaded direct into the truck. To avoid breaking the underdrains, a double layer of planks, at right angles to each other can be used.

(e) *Disposing of Sludge.*—Sludge has fertilizer value and in some cases farmers will haul it away, but they will rarely pay for the sludge itself. In some cities, the park department uses the sludge on grass and shrubs. For such use, the sludge generally should be ground, as the lumps in unground sludge take some time to break up. Some of the sludge produced can be used around the treatment plant for fertilizing grassy areas and shrubs. This is the best method of advertising both the value of the sludge and the quality of operation of the plant.

(f) *Using Chemicals.*—Various chemicals have the property of expediting the drying of the sludge through improving its drainability. These are especially valuable where there is a lack of bed area. The ones principally used for this purpose are ferric chloride and aluminum sulphate. Ordinary applications are 5% or 6% by weight of the dry solids in the sludge. Computations for determining the amount of chemical needed are as follows: Assume a bed 20 ft. by 20 ft. to be covered with 12 inches of sludge having 2% solids and 98% water. Weight of sludge the same as water, or 8.3 pounds per gallon or 62.5 lbs. per cubic foot.

A bed 20 x 20 contains 400 sq. ft.; and when 12 ins. of sludge is drawn contains 400 cubic feet of sludge. At 62.5 pounds per cubic foot, this sludge weighs 25,000 pounds. If 2% of the sludge is solid matter, the weight of solid matter is 2% of 25,000 or 500 pounds. If 5% of the chemical is to be applied, the amount required would be 500 x .05 = 25 pounds.

The chemicals are usually added as a solution just as the sludge is flowing onto the bed, as the reaction is very rapid.

(g) *Winter Operation.*—Often beds offer some difficulties in winter operations, particularly when heavy ice or snow storms, followed by freezing weather, occur after the sludge is partially dried. However, sludge may be placed on beds, particularly covered beds, in freezing weather. If frozen sludge can be removed without taking too much sand, and stockpiled, it will be found very desirable for use on lawns, after thawing and drying, as it tends to powder easily.

It is particularly important that all sludge lines (as well as any other lines carrying liquids) should be drained completely to prevent sludge from hardening in them, and also to prevent freezing in the winter.

(h) *Records of Operation.*—At the time the sewage is drawn a record should be made of the date, the number or designation of the bed onto which the sludge is drawn, the depth of the wet sludge and the number of cubic feet drawn. When the sludge is removed from the bed, the date and number of the bed being cleaned should be shown, and also the depth of the dried sludge, the length of time it has dried, and the number of cubic feet or cubic yards removed. When the sludge is drawn to the beds, an examination to show the solids content, the volatile solids and the pH should be made. Likewise the moisture content of the dried sludge should be determined. All these factors should be noted on the records of operation.

(i) *Vacuum Filters.*—Vacuum filters are used for rapid dewatering of sludges. They are suitable for either raw or digested sludges removed by primary or secondary treatment plants. Sludges containing 85 to 98% moisture are rapidly dewatered, producing a filter cake 65 to 75% moisture.

A vacuum filter installation consists of sludge pump or bucket elevator, chemical feeders, sludge conditioning tanks, vacuum filter, vacuum receiving tanks, moisture trap, dry vacuum pump, filtrate pump, blower, filter cake conveyor and sludge cake hopper. Filtering is accomplished through a cloth medium on a drum rotating in a container of sludge. The filter cake is removed by air pressure and a scraper onto a conveyor.

When sludge is properly conditioned, yields of 4 to 7 pounds of dry solids per sq. ft. of filter per hour are obtained while dewatering plain settled and chemically precipitated sludges, in either raw or digested condition. Chemical required for most efficient and economical operation for such sludges amounts to about 2% of ferric chloride and 10% of lime, figured on the dry solids in the sludge. The moisture of vacuum filter cake will average from 65 to 70%. Activated sludge mixed with plain settled sludge requires about 5% ferric chloride and yields about 2 or 2½ lbs. dry solids per sq. ft. per hour. Activated sludge alone yields about 1 lb. of dry solids per sq. ft. per hour, and the cake has a moisture content of 80 to 85%. In each case the operator must determine by trial the chemical dose most suited to the sludge with which he is working.

In order to be sure that the sludge is properly conditioned, it is better when starting filtration to increase the chemical dose about 50% above the normal for about a half hour and then gradually reduce the dose to a normal amount, until just the right cake is being obtained. When the proper chemical dose is obtained, the cake will be discharged cleanly from the cloth without sticking.

Whereas, sand sludge drying beds require from ½ to 1 sq. ft. per capita, 1 sq. ft. of vacuum filter area is suitable for a population of 160 for raw activated to 1,280 people for primary digested sludge. Other types of sludge come in between these figures.

Vacuum filters are usually operated during the day shift, with 6 hours actual operation, and one hour for starting and one hour for washing up. Where vacuum filters precede incinerators, their operation must be coordinated to meet the requirements of the incinerator.

The filter cloth should be washed with water, after each day's run, by turning on the water sprays and opening the drain valves. When the cloth has become blinded, it is more economical to install a new cloth, than to operate with a dirty one. Under normal conditions, cloths can be operated for 6 to 10 weeks without changing. It is also important that the grease cups and oil wells be checked at least once a day.

For alkaline conditioning, that is, where lime and ferric chloride is used, cotton cloths are suitable, whereas if ferric chloride alone is used for conditioning, it is necessary to have a woolen cloth.

Before starting operation of a vacuum filter installation, the operator should obtain full instructions on chemical dosages and mechanical operation and care, from the filter manufacturer.

XV.—Maintenance of Equipment

1. *Metering Devices.*—Weirs and float wells must be cleaned daily to prevent the accumulation of solids and grease. Weir plates should be maintained sharp and straight. When dosing chambers are used for flow measurement, particular attention must be paid to

keeping these free from accumulations of solids. Parshall flumes must be kept free from grease and adhering scum and the float well flushed frequently. Venturi tubes should be cleaned 2 or 3 times a week.

Float gauges should be checked monthly by lowering the liquid elevation to the crest level, at which time the pointer should be on the 0 mark. If it is not, the calibrated portion of the gage should be adjusted. Indicating, recording and integrating flow instruments should be checked by dropping the liquid to the crest (on Parshall flumes) or by equalizing the liquid level or pressure in float tubes or chambers in the case of Venturi tubes. Unless the operator is experienced in this work, he should ask the manufacturer for instructions.

Charts should be changed at the same time every day. Records maintained should show total flow, the maximum rate of flow and the minimum rate of flow, all in m.g.d.

2. *Sludge Pumps.*—Sticks, rags or other solid objects may clog the valves of reciprocating sludge pumps, holding them open. On pumps which have a pressure gauge on the discharge side of the pump, the fluctuations of the gauge needle provides a good indication of the operation of the pump. No fluctuation indicates that the inlet valve is being held open; a greater than normal fluctuation indicates the discharge valve is not seating. Quick-opening hand-holes are provided through which obstructions are removed. The pump and the area around it should be kept clean. Air should be kept in the air bell. Operating, lubricating and maintenance instructions provided by the manufacturer should be followed.

3. *Sewage Pumping Stations.*—Centrifugal pumps are used almost exclusively in pumping sewage, normally operating at speeds of around 1150 r.p.m. Pumps are set (1) submerged in the sewage in a wet well; (2) in a dry well below the sewage level in an adjoining sump or well; or (3) above the sewage level and raising the sewage by a short suction line. The second method is generally preferable.

Since the cost of pumping, where this is necessary, is usually a large item in the cost of operating the plant, special attention should be given to maintaining the pumps in an efficient operating condition. Pumps that are partly clogged, have inlets that develop excessive friction or entrance losses, or have worn or improperly designed impellers may contribute to excessive power charges. Improperly maintained pumps may fail, which in a sewage plant is almost always a major disaster and may create a health hazard.

Wet wells should be drawn to the minimum elevation daily, and (1) deposits removed; and (2) walls and bottom thoroughly flushed with a heavy stream of water. Grit accumulations should be removed at regular intervals. Grease accumulations in float tubes should be removed daily by flushing or other means. Screens should be cleaned daily or oftener, as indicated by the amount of screenings accumulated, and these should be carefully disposed of as already indicated under SCREENING. Water that accumulates in the dry well should be removed daily.

The pumping cycle is normally controlled by floats and sequence switches. Where pumps of different capacity are installed, the smaller pump should cut out when the larger one starts (and vice versa); both should operate only under peak loads. Where there are 2 or more pumps of the same size, they should be alternated to provide equal wear. Standby pumps should be operated once each week for a short period to insure they are in proper condition and to dry out motor windings.

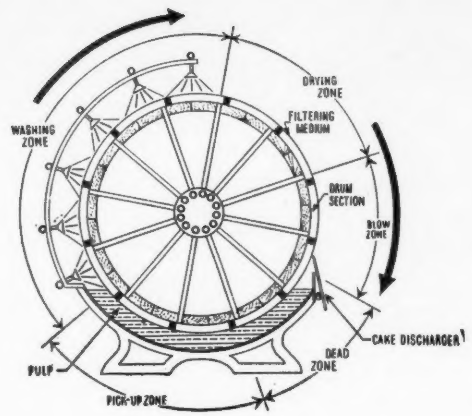


Fig. 19. Section of an Eimco vacuum filter.

All bearings, motors and electrical control equipment should be inspected daily for overheating. The manufacturer's directions for operation and lubrication should be studied and followed carefully. Packing glands should also be inspected daily. Excessive tightness should be avoided, a packing being too tight when the shaft cannot be rotated by hand. Use the packing recommended by the manufacturer of the pump.

Operation of the pump briefly in reverse is sometimes effective in preventing clogging, as this tends to free material caught in the impeller. A reversing switch must be installed on the control board to permit this. Operation in reverse should not exceed one or two minutes.

Trouble-Shooting.—The following list of operating troubles is taken from the R&U Manual, Corps of Engineers, material for which was largely based on "Standards of the Hydraulic Institute." Much of the above data on equipment maintenance and operation is based on the R&U Manual.

(a) No flow from pump: (1) Impeller may be clogged; (2) pump may not be primed; (3) the pump may be operating in the reverse direction; (4) suction lift may be too high; (5) the discharge head may be too high or (6) the pump speed is too low.

(b) Small flow: (1) Impeller partly clogged; (2) air leaks in the suction or the stuffing box; (3) air entering suction due to swirl of sewage in wet well or insufficient depth of suction; (4) partly closed valve; (5) discharge head too high; (6) or improper design of impeller.

(c) Not enough pressure: (1) Air in the sewage; (2) impeller too small; or (3) speed too low.

(d) Pump works for a while and then loses suction: (1) Leaky suction line; (2) suction lift too high; (3) air or gas bubbles in the liquid; or (4) water seal plugged.

(e) Too much power required and motor overheats: (1) Speed too high; (2) head is lower than pump rating and too much water is pumped; (3) mechanical defects such as tight stuffing box, bound impeller, worn wearing rings, bent shaft, out of line, or improper lubrication.

(f) Low speed: (1) Low voltage; (2) defective electrical contacts; (3) motor overloaded.

(g) Pump starts but overload relays kick out at once: (1) Impeller bound or packing too tight; (2) defective starting relays; (3) improper oiling; (4) voltage too low or too high; (5) defective motor, wiring or switches.

(h) Excessive vibration or noise: (1) Shafting out of line; (2) bearings worn; (3) lack of lubrication;

(4) unbalanced or worn impeller; (5) worn bearings.

General: In some cases where the discharge line is long and the lift high, check valves may slam due to water hammer. Spring-loaded relief valves may be installed or an air chamber connected to the line, with a small air compressor to replenish the air from time to time.

When the line has summits and low spots, air tends to collect at the high points and clog the line. Air relief valves should be placed on such high points.

XVI.—Other Factors

Safety in the Sewage Plant.—Some of the precautions to be taken in regard to liquid chlorine have already been mentioned. Gas poisoning and gas explosions are other hazards. The gas produced by sludge digesters is explosive when mixed with at least 5 times, but not more than 19 times, the volume of air. Therefore smoking or carrying open flames in or around digesters is hazardous. In pump pits or other covered and enclosed places similarly explosive gas often gathers and precautions are necessary in entering them to prevent explosions. Also, the gases contained may be fatal to anyone who breathes them. Therefore covered tanks or pits should be well ventilated by blowing air through them before being entered; anyone entering them should fasten a rope to his body, and an assistant should remain outside holding the other end of the rope and ready to help.

A first aid kit and a gas mask should be a part of the equipment of every plant. Be sure to note if this mask protects against chlorine and against carbon monoxide also. Individual gas masks are serviceable for protection against only a few gases. Therefore a mask designed to serve against ammonia may be of no use whatever against chlorine.

It is desirable to protect tanks by railings to prevent attendants or visitors from falling into them. Gears and other moving parts should be screened or guarded.

An excellent article on safety in the sewage treatment plant was published in the August, 1938, issue of PUBLIC WORKS.

General.—Keep a set of the blueprints showing details of the plant. Some of these may be framed and hung on the walls, not so much for decoration as for ready reference and preservation. Prints handled frequently rapidly wear out. Pumping installation, pipe layouts, and similar material that is needed for more or less frequent reference can be kept under glass.

Keep your own copy of your monthly reports to the State Department of Health, and study them from time to time. Familiarity with what has been done and the results obtained is of most value in efficient operation. Written records are best, as memory is sometimes unreliable. Experiments should be written up in a note book, whether results are favorable or unfavorable: also unusual events in operation. A loose-leaf book is desirable but not necessary.

Plant beautification should not be neglected. Plant shrubs, flowers and grass and keep the grounds clean, neatly mowed and trim.

A library should be maintained at every plant. This should include *Standard Methods* and at least a couple of recent texts on sewage treatment; also some of the many excellent bulletins and pamphlets issued by manufacturers serving this field. Read your technical magazines; the Sewerage Digest section of PUBLIC WORKS will keep you informed on what has been published. Join your Sewage Works Association, or at least attend its meetings. Enroll for some of the short courses now being given in almost every state. And if you need help, write the Editor of PUBLIC WORKS.

Safety on Highways in Winter

Reporting on maintaining safe highways in winter, a committee of the National Safety Council says:

"It is a major function of state and city highway departments to keep roads open and in safe condition for winter use. The problem is largely one of ice and snow removal or treatment in those states within the snow belt.

"Maximum safety is provided when snow and ice are completely removed, leaving a bare pavement surface. This is a highly recommended practice, especially on heavily traveled streets in metropolitan areas.

"Where complete ice and snow removal is impractical, abrasives treated with chlorides should be freely spread at all intersections and other points where stop and go driving prevails. Complete sections of highways should be so treated if they carry heavy traffic volumes or have experienced a high number of accidents involving an icy or snowy roadway.

"The study made by the committee indicates that sand and cinders are widely used as abrasives on ice and snow. Sand is most commonly used by both city and state highway departments. Approximately equal use is made of chloride-treated and untreated sand and cinders. Only one state and two cities reported the use of heated sand and no state or city indicated the use of heated cinders.

"The general practice by highway departments, according to the study, is the application of abrasives only at intersections, on steep grades, on curves, and at other critical locations. A number of states and the majority of cities, however, are applying abrasives over the full length of important highways."

Fundamentals for Designing Low Dams

(Continued from page 16)

channel may be blasted around the dam. This should be smoothed and paved, and sidewalls should be constructed. Where rock does not exist, a channel of proper dimensions may be excavated around the dam (the site of the dam should be selected to provide adequate spillway capacity). The excavated section should be paved with 8 to 12 ins. of concrete or 18 inches of rubble masonry; and side walls should be built up to a height sufficient to prevent overflow.

Special attention should be given to the outlet of the spillway, which should be so constructed as to prevent erosion. The outlet must be so alined that the spillway will discharge in the direction of the flow in the original stream bed, with a minimum of interference, thus reducing any tendency to erode at the toe of the spillway.

m. Materials for Earth Dams.—By using properly graded and compacted soil, an extremely dense earth dam can be constructed, which will be practically impervious to leakage and resistant to erosion. The first step is to make, or have made, sieve analyses of the soil it it intended to use. The State Highway Department will advise on such procedures. On any dam involving a cost of several thousand dollars, it will pay to purchase the equipment necessary to perform the tests. In addition to the sieves, equipment should be

available to perform compaction tests, as follows:

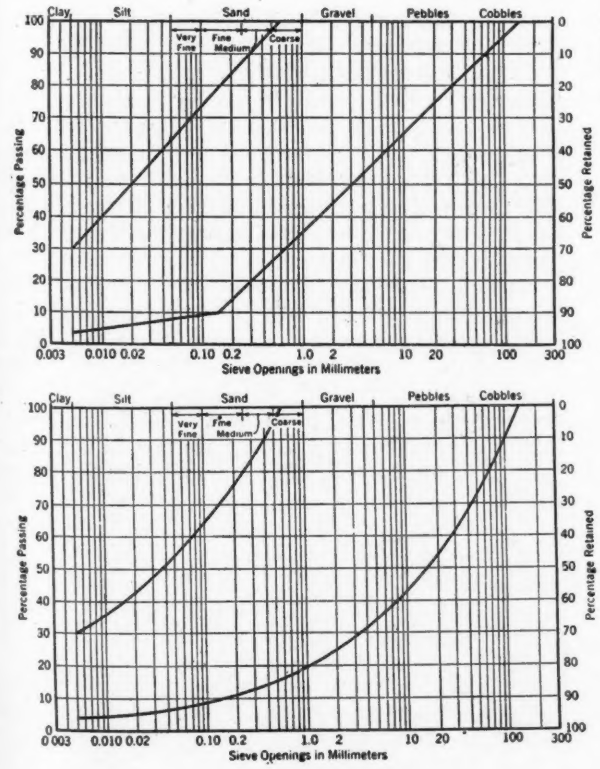
Compaction cylinder and rammer; Plasticity needle; Cenco triple beam balance; Soil auger and three extensions; No. 4 sieve; Spatula, 3½" blade; 1 dozen. 6 cm. diam. evaporation dishes; Gasoline camp stove and oven; Spring balance, 30 lb. capacity.

The cost of this equipment is about $125. The additional equipment needed to perform all tests for the selection of the material, costing about $40 additional, is:

Attachment to compaction cylinder; No. 40 sieve and pan; Two 12 cm. diam. evaporation dishes; 400 c.c. beaker; 25 c.c. graduate; 25 c.c. burette.

n. Gradation.—In grading soils to obtain a dense mixture, the same general principles are employed as in making good concrete. The clay, sand and gravel are so proportioned that voids are filled. The theoretical amount of clay is not generally enough, and in practice around 15% to 20% will be needed. Fig. 7 (from a paper by Charles H. Lee before the American Society of Civil Engineers) shows reasonable limits for ungraded materials and Fig. 8 for graded materials for impervious sections of rolled-fill earth dams. For suitable materials, curves should lie between the limits shown, generally parallel to them, and of a shape reasonably corresponding to them. It should be remembered that the ½" opening corresponds to 12.6 m.m., the 10-mesh to about the 2.0 m.m., the 40-mesh to 0.5 m.m., etc.

The characteristics of the soil under consideration so far as grading is concerned, can be determined by sieving and plotting on a chart similar to Fig. 7 or Fig. 8. In addition to the proper gradation of particle size, soil must be insoluble. It should, of course, be available at a reasonable cost. Other factors commonly included in considering the suitability of soils include stability, watertightness within reason, and workability. Properly graded and compacted soils meet these requirements.



Figs. 7 and 8. Lee's curves.

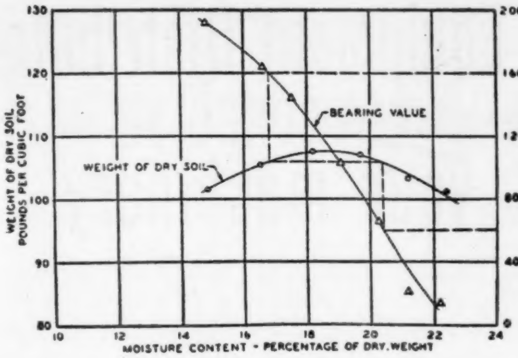


Fig. 9. Curves obtained from compaction data.

When soil is not available of the desired character, sieve tests will show in what way it is deficient—whether in fine material or in coarse. It may be economically possible to make up this deficiency by adding clay or sand, as needed, during construction.

o. Moisture Content.—A soil suitable and properly graded being available, the next problem is to determine its optimum moisture content for compaction.

In making the compaction test (which was devised by R. R. Proctor), about 5 pounds of dry soil passing the No. 4 sieve is thoroughly mixed with just enough water to make it slightly damp, compacted in a cylinder, the sample weighed, the bearing value determined by the needle and the moisture content determined by drying in an oven. This procedure is repeated, each time increasing the amount of water enough to raise the moisture content about 1%, until the soil becomes wet and there is a decrease in the wet weight of the unit volume of compacted soil. Fig. 9 (which was sent us by C. A. Hogentogler, Jr.) shows the two curves resulting from this test. It will be noted that for this soil a moisture content of about 19% is required for maximum compaction; while for this condition, the bearing value of the soil is about 1,100 pounds per square inch.

It will be noted also that, with the moisture content at about 19%, the weight per cubic foot of dry soil is at a maximum of about 108 pounds. The bearing value of 1,100 pounds at the 19% moisture content is greatly exceeded by the bearing value at about 17% moisture. But the weight per cubic foot of dry soil is less, the moisture content is not stable, since, as shown by the dotted line of Fig. 9, additional moisture may be taken up, even beyond 20%; and at a moisture content of somewhat over 20%, the bearing value is only 500 pounds.

This optimum moisture content should be determined for the soil or soils selected for the dam, and maintained during construction by sprinkling the fill or by spreading the dirt in thinner layers and allowing it to dry before rolling.

No frozen materials should be used for dam construction.

p. Foundations.—For earth dams less than 25 ft. high, the ability of the foundation to carry the dam will rarely present a question, unless there is a stratum of material that is or may become plastic. When this occurs, this stratum may be removed, the foundation carried below it, or another site chosen. Soft and mucky areas should be removed.

The most suitable material on which to place an earth dam is clay containing a small amount of silt or sand. In preparing the foundation, all sod, brush, trees, roots, and other perishable matter should be removed

from the entire area to be occupied by the dam, which material should not be used in the dam. The entire area to be covered by the dam should be plowed or scarified to insure a firm bond between the dam and the foundation.

If sheet piling is to be used, it may be driven along the center line of the dam without constructing a trench. In the case of low dams, it should be driven to a depth of at least half the height of the dam, and should extend through any pervious strata of gravel or sand. If deep strata of sand and gravel are encountered, the site should be abandoned and a new site located. When a core of puddled earth is used instead of sheet piling, a trench should be excavated having a minimum width of 3 feet, and deep enough to extend into the impervious stratum a minimum of 2 feet beneath any stratum of gravel and sand.

The area of stream banks that will be covered by the dam should be sloped and then scarified, the amount of slope depending on the soil. This will reduce the tendency to form shrinkage cracks along well-defined planes and produce more equal settlement.

(To be continued)

Rock Springs, Wyo., Subway-Viaduct

(Continued from page 11)

pass at "A" Street, and a pedestrian subway at "C" Street. Plans were accordingly prepared on this basis and the project was advertised for bids on May 23, 1940, and the contract awarded to The Frank M. Kenney Construction Company of Denver, by the State Highway Department. Kenney began construction of his part of the project at once, and completed his work about May 15, 1941.

The city, in order to complete its part of the project, acquired title to all the necessary lands occupied by the project, and in addition, on August 5, 1940, awarded a contract to The Woodward Construction Company for the street paving made necessary by the construction of the project. Woodward completed his contract on May 29, 1941, and on May 30, 1941 the project was thrown open to traffic.

In the construction of the concrete work, use was made for the first time in Wyoming of absorptive form lining, which material was used throughout in the structures. At first an attempt was made to use concrete having a very low slump, but when the forms were stripped it was seen that the concrete was too harsh, and change was made to use of about 2″ to 3″ slump. Good results were obtained thereafter, but it was noted that wherever the vibrator touched the form lining the texture of the surface was marred, so special precautions were taken to insure that this did not occur. The structures were of reinforced concrete construction with rolled steel beams. The "A" Street overpass has a central main span of 94 ft. composed of plate girders fabricated to conform to a 240-ft. vertical curve. The "M" Street subway was designed for standard E-72 loading.

The paving work done by the city involved the use of Warrenite-Bitulithic pavement in widening of existing streets having this type of pavement, and the use of bituminous macadam pavement on the new streets created by the project. Crushed rock obtained locally was used for this type of pavement, and 95+ asphalt was used as the binding agent, using about 2.5 gallons per square yard. Very good results were secured.

The structures were constructed by The State Highway Department of Wyoming, of which Frank Kelso

is superintendent and C. F. Seifried is chief engineer. R. C. Pike was resident engineer for the Highway Department.

Albert E. Nelson was Mayor of Rock Springs, and the writer was city engineer during the construction of the project.

Timber Bridges in Germany

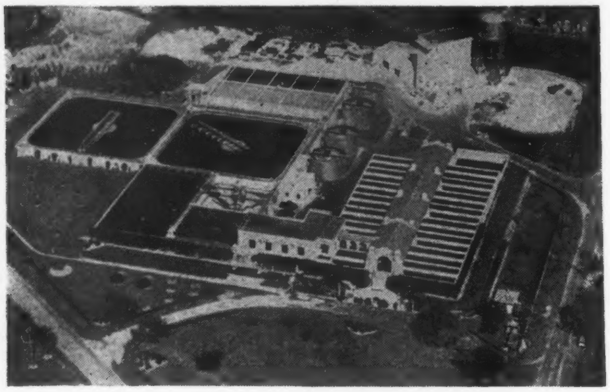
According to the German paper "Strasse," the possibilities of timber construction have recently been extended by the introduction of new types of connectors (double-cone, plate, and ring types), by the improvement and standardization of screws, bolts, and nails and by advances in design, notably that of joints. Effective methods of preserving and fireproofing structural timber are also available. The disadvantages include: (1) the variations in density, grain, cleavage, etc., in both different woods and different specimens of the same wood; (2) swelling or shrinkage caused by variations in moisture content; (3) the tendency to warp or split, especially at joints. Frequent inspection and careful maintenance are therefore required.

Timber has been employed for many footbridges and light bridges over the German motor roads, and during the war its use, especially for emergency bridges, has greatly increased in both Germany and the occupied areas. Official requirements regarding timber construction provide that emergency bridges must comply at least with the loading requirements for Class II bridges: bridges carrying heavily trafficked roads, and those in large towns and industrial districts must satisfy the requirements for Class I bridges. For one-way emergency bridges the minimum carriageway width is 11 ft.; for two-way bridges, 20 ft. The usual type is the trestle bridge with simple or dowelled beams, nailed, rolled or plate girders, and a plank deck. A combination of nailed timber and steel girders is better than all-timber girders in that the spans are longer, reducing the number of piers required and therefore the time needed for pile-driving. Nailed timber box girders are comparatively light and can be easily assembled and erected. They are suitable for spans of 33 to 66 ft.; for longer spans nailed lattice girders can be used. Steel rolled and plate girders are always to be preferred where stocks and workshops are at hand or where a sufficient number of suitable girders is obtained from a wrecked bridge. Class II emergency bridges may carry vehicles up to 20 tons total weight travelling singly, or spaced at least 66 ft. apart, at low speeds.

Suggestion for Patching Oiled Streets

The Superintendent of Public Works of the City of Zion, Ill., Louis Anslyn, sends us the following description of a method of patching oiled streets that he has found to be a material, time and money saver.

"We have 22 miles of oiled streets. For several years we trailed our small road oil tank behind our truck of gravel. We put hot oil in the hole, filled the hole with gravel, sprinkled a little oil on top, then a thin layer of gravel. We used crushed gravel with about 20% clay binder and 25% sand. This proved to be a slow, expensive method; so we took one of our older trucks, put a 3 inch layer of gravel in it, poured 10 gallons of hot oil on it, then another 3 inches of gravel, etc. In this way we were able to patch all our streets in one week, where the old method took three weeks. We have tried this method for two years now, and find the patches stay as well as or better than by the old method."



Aerial view of the Miami, Fla., water purification plant.

The Waterworks Digest

Abstracts of the main features of all important articles dealing with waterworks and water purification that appeared in the previous month's periodicals.

Mutual Aid in New York State

Papers are published in the A.W.W.A. Journal describing "The Mutual Aid Plan at Work" in three states. One of the best appears to be New York's, where, after eight months of operation, the following have been accomplished:

1. Of a total of 274 proposed inter-system connections, some 200 have been installed. 2. 371 communities have submitted maps of water supply distributing systems. 3. 341 communities have made surveys of possible emergency water supplies. 4. 187 communities have made surveys of their water distribution systems for weaknesses. 5. 49 communities have made special studies of water service and fire protection to defense industries. 6. 25 communities have made special studies in co-operation with power officials. 7. 45 communities have already undertaken the organization and training of auxiliary water works personnel. 8. 162 communities have given special attention to protection against possible waterworks sabotage. 9. 684 communities have submitted inventories of water works equipment, materials, supplies and personnel. The last, in ready reference form, makes it possible to arrange promptly for the loan of needed material and equipment.[A106*]

Cathodic Protection Of Steel Water Tanks

Tests of this, begun in October, 1940, are being conducted by the Baltimore, Md., Bureau of Water Supply in three 10" x 36" pieces of w. i. pipe. No. 1 has negative terminal of rectifier attached to pipe and positive terminal to suspended 1" graphite rod. No. 2 has positive terminal attached to pipe and negative to a ¼" stainless steel rod electrode. No. 3 was a control tank without electrode. A potential of 9.5 volts was applied to No. 1 with a resulting current of 40 milliamperes; in a few weeks a deposit of calcium carbonate began forming on the tank surface. No. 2 showed great corrosion. No.3 at first showed little corrosion, owing to mill scale, but after two months showed streaks of corrosion. All tanks had 172cc of water per minute running through them. After 14 months No. 1 was in fine condition. No. 2 was in bad condition, with a deep uniform layer of soft and fluffy rust. No. 3 was badly rusted in vertical streaks, with dense and hard tubercles. This method is believed effective if properly installed and cheaper and more effective than painting. The surface down to 3 ft. below normal high water should be painted with a special bakelite base paint or hot pitch. Stainless steel electrodes, 30% chromium, were preferred to graphite rods. Results can be improved by several devices described in the article.[G34*]

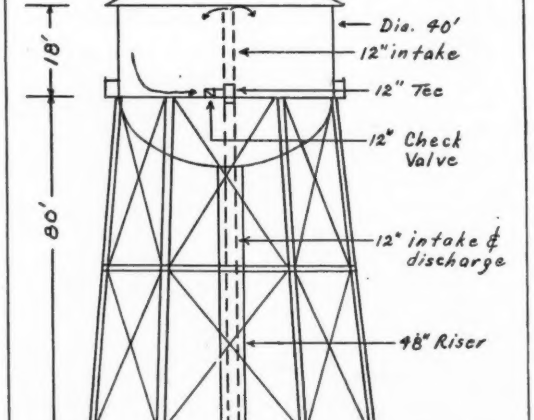
Keeping Fresh Water Fresh

A 250,000 gal. elevated tank in a small community was necessary for fire protection, but the daily domestic consumption was only one-seventh of this capacity. To keep the water fresh, a 12" inlet was installed inside the 48" riser to a point slightly above the tank overflow, and in this just above the bottom of the tank was placed a 12 x 12 tee with a horizontal swing check valve, so that all water must enter the tank over the top of the 12" pipe but leave through the tee. The pump, a mile away, automatically starts when the water level in the tank drops 2 ft. and stops when the tank is full; pumping continuing 3 to 4 hrs. about twice a day. Cost of current for the additional head pumped against is about 5 cts per million gallons.[G42]

Cooperative Ground-Water Investigations

In 1938 the U. S. Geological Survey, in cooperation with the Massachusetts Dept. of Public Works, began an investigation of the ground-water resources of Massachusetts, the chief purpose of which has been to secure detailed information concerning the occurrence and availability of ground water in that state. It includes an inventory of existing wells and collection of related information, such as well logs and construction, water-bearing formations, depth to bed rock, depth of well, yield, ground-water level, etc. Measurements of ground-water levels are now being taken monthly in 37 wells, 3 having automatic water-stage recorders. These are compared with precipitation records.[B19]

Similar investigations are being made in Connecticut, chiefly in the New Haven area, by cooperation of the U. S. Geological Survey and the State Water Commission.



Courtesy Water Works & Sewerage

250,000-gallon tank equipped for keeping fresh water fresh.

*See Bibliography in the September issue.

Such studies began in 1903 to 1929; were renewed in 1934 as an FRA project and in 1935 as a WPA; then taken over in 1939 by the cooperation first mentioned. Studies in New Haven are being made of residential, air-conditioning, cold-storage, and industrial areas. Of a total pumpage of ground water of 3.71 m.g.d., 2.57 is for industrial, 0.62 cold storage, 0.32 air conditioning and 0.20 residential purposes. Samples are tested monthly for chloride content, which has varied from 24 p.p.m. to 3025 p.p.m.[B20]

Taking Over a Private Distribution System

The plant of the Amoskeag Manufacturing Co., in Manchester, N. H., established in 1810, in 1936 covered 170 acres. It was served by a self-owned water distribution system that took its supply from the river and included 12 miles of 4" to 24" mains, and 150 miles of 8" to 1" pipe inside the buildings. It was cross-connected to the city supply at three points, protected by double check valves. In 1936 the company went out of business and its successor arranged with the Manchester water works to take over the Amoskeag water system and supply water through it, thus eliminating the danger of river water cross-connected to the city supply. The city decided to use eight miles of mains as public mains, the others to be considered as private ones belonging to the mills, or abandoned.

The most important problem was cleaning and sterilizing more than 160 miles of old pipe, which were partly filled with silt. First, 11mg of river water in the Amoskeag reservoir was used to flush the mains through the fire hydrants, which brought out most of the mud. Then city water was used, flushing the pipes in the opposite direction. The city pressure was 20 lb. more than that from the Amoskeag reservoir and brought out large quantities of coarse material. Then the mains were sterilized. All city water reached the property through a 16" main, and over this was constructed a small building housing two Proportioneers pumps, one for chlorine and one for ammonia. A 12½% solution of sodium hypochlorite was used and 29% B. E. ammonia solution. (Copper tubing was used between pumps and main and became somewhat corroded during the operation.) The chlorine entered the main 8 ft. ahead of the ammonia. A constant dose was continued for 24 hrs. a day, varying from 2 ppm at night to 0.5 ppm at peak flow. The water was being used by the mills meantime and hydrants were opened also. Chlorine absorption was low, the residuals at different distances from the plant varying from 0.15 to 1.0 ppm 48 hrs. after starting. This was continued for 6 weeks. Then the smaller mill pipe lines were bled until residuals appeared at every dead end. This sterilizing continued for about a month. The process was then repeated, and all the water was brought to drinking water bacterial standards.[B26*]

Blood Worms In Water Supplies

Red worms that appear in water supplies are usually the larvae of chironomid midges, which deposit their eggs in water, principally pools and slowly flowing streams. The egg masses usually float near the surface. In about six days the larvae appear, many of them bright red, others green, yellow or bluish, depending on the genus. The larvae feed mainly upon plankton and decaying vegetation, possibly including E. Coli if present. They may live from 4 to 5 months to 2 years, before the pupae stage, which lasts only from a few hours to a few days. The pupae remain in the bottom mud and are rarely found free in water. The larvae and pupae are the chief food of a number of fishes, including bass, trout and whitefish.

A reasonably effective treatment plant should eliminate all the larvae, though chlorination will only kill them, and possibly not reach bacteria in their intestines. They were controlled in two lakes in the New York Worlds Fair grounds by spraying chlorinated benzenes under the surface of the water. Copper sulphate eliminates them in large reservoirs. They may appear in distribution reser-

voirs holding purified water, which can be prevented by keeping the midges out by covering with all air vents screened.[F68*]

Venturi Meters At Windsor Dam

Windsor dam forms Quabbin Reservoir, part of the Boston, Mass., water system. The supply leaves the reservoir through three pipes of 12", 24" and 48" diameter, the last entering a 60" conduit. The flow is measured by three Venturi meters, as follows: 60" x 33", minimum flow 28 cfs, maximum, 223; 33" x 19", min. flow 9 cfs, max. 75; 12" x 7", min. flow 1.3 cfs, max. 10.2. These are the flows that can be measured, and discharges are limited to these by control valves; but if desired the meters will pass 560, 180 and 20 cfs respectively. Air entrained in the water is released under the negative pressure in the throat of the meter, whence it is removed automatically by a vacuum pump. All pipes, valves and venturi mercury wells are in a basement level with the bottom of the outlet channel, the mercury wells being 2.5 ft. below the floor, to insure greater than atmospheric pressure on the inlet ring mercury well. To prevent too great water pressure on the piezometer pipes, which would blow out the mercury, a valve on each inlet pipe is automatically closed when a predetermined head is reached.[F71*]

Air Entrainment in Spillway Channels

In designing chutes or steep spillway channels, freeboard allowance should be made for the entrainment of air by the high water velocities; also difference in frictional resistance allowed for. Data were collected by study in actual spillway chutes. These showed that flow on steep gradients is essentially different from that at ordinary slopes. Velocities are greater than the critical—from 10 to 100 ft. per sec., and kimetic energy greatly exceeds the static pressure of the water prism. Q does not equal Av unless A be reduced to allow for entrained air. Water near the surface in the center of the channel has a velocity 15% to 20% above the mean. Super-elevation of the water surface on curves corresponds to that computed by the centrifugal theory.[K6]

Metallizing In the Water Plant

Erie, Pa., began metallizing in 1930. In 1934 a corroded 110,000 gal. steel wash water tank was given a .006 in. coating of zinc, which is still in perfect condition. The corroded surfaces of 128 steel washwater troughs in the filters were coated with zinc .006 in. thick in 1936 at a cost of $7,962, including $4,526 for labor in removing and replacing filter sand, scraping the troughs, etc. Other work done was rebuilding bronze and steel valve rods and pump plungers. The built-up sections are giving more satisfactory operation and longer service than the original pieces because the metal or alloy best fitted for the part was sprayed on and also because sprayed metal absorbs and holds lubrication more readily than others. Lead, tin, zinc, babbitt, aluminum, bronze, brass, copper, nickel monel, iron, and steels (high, medium and low carbon and stainless) are used in spraying.[G41]

Acid Treatment Quadruples Well Flow

At a midwest ordnance plant a 10 in. well drilled 901 ft. through various rock formations to mixed sandstone and dolomite yielded only 152 to 170 gpm—much less than needed. An electric log of the hole was made by use of an electrograph, which virtually photographs the several formations penetrated, the porosity of the rock being determined from measurements of resistance to an electric current. This indicated water in porous, sandy dolomite

formations at 340-350 ft. and 375-390 ft. To increase the flow, the well was treated with inhibited hydrochloric acid, which dissolved portions of the rock, enlarging the pores. (Inhibiting the acid prevented its attacking the well casing, pumps, etc.) Most of the water in the well was pumped out and a charge of 250 gal. with 30% acid was mixed with about 250 gal. remaining in the well, giving 15% concentration; and at intervals during the next two hours 2,250 gal. of acid solution was added. Then clear water was pumped into the well under 25 to 10 psi pressure, forcing the acid back into the rock. Several hours later pumping was started and yielded nearly 1,000 gpm.[E20]

Lining Cast-Iron Pipe in Place

Nine years ago Waterbury, Conn., laid part of a cast-iron supply main from its reservoir but did not complete it, or use that already laid, until this year. Then it had the main lined with cement ¼ inch thick. The pipe already laid consisted of 9,400 ft. of 36" pipe and 1,300 ft. of 42" pipe. The pipe was first cleaned and the paint removed by means of machine with a rapidly revolving shaft in the center of the pipe, one end of the shaft carrying several pieces of chain of such length that, as the shaft revolved, steel castings on the ends of the chains abraded the pipe and also roughened it so that the cement adhered better. As this machine traveled through the pipe, a blower caused a draft that carried paint fumes and dust away from the operator. About 1,000 ft. a day was cleaned. Then it was lined at the same rate by a somewhat similar machine that applied cement mortar to the pipe by centrifugal force and troweled it smooth. Six-foot sections of pipe were removed at 1,800 ft. intervals to provide access, and were replaced, using Dresser couplings, before the lining machine reached the opening.[E22]

Air Pockets In Water Mains

If an air pocket forms at the summit of a pipe line or beyond a partly opened gate it can be removed by use of an air valve unless the pipe is under sub-atmospheric pressure. An hydraulic jump ordinarily occurs beyond an air pocket and experiments with transparent pipe indicate that it will entrain more or less of the air in the pocket, but below a certain critical condition the pipe beyond the jump will not remove all the air the jump can entrain.[K7]

Bacteria in Pipe Corrosion

Some forms of bacteria, chiefly Anaerobic, have much to do with corrosion of iron and steel. There are two groups—sulphate-reducing and iron consuming. They may not be directly responsible for corrosion but their presence results in the formation of chemical compounds that either directly attack the metal or establish conditions conducive to electrochemical attack. They can be eradicated by chlorine or chloramine treatments, or by a good coal-tar base enamel coating on the metal.[G37]

Bibliography of Waterworks Literature

The articles in each magazine are numbered continuously throughout the year, beginning with our January issue.

c. Indicates construction article; *n*, note or short article; *p*, paper before a society (complete or abstract); *t*, technical article.

A *Journal, American Water Works Ass'n*
September

112. Water Service in Wartime London. By Henry Berry. Pp. 1298-1327.
113. Effects of Air Attack Upon Utility and Other Structures. By Walter D. Binger. Pp. 1328-1334.
114. Water Supply Protection in Civilian Defense. By Ralph E. Tarbett. Pp. 1335-1342.
115. Chicago Civilian Defense Plans for Water Safety Control. By Arthur E. Gorman. Pp. 1343-1356.
116. Investigations of Water Works Protection in Ohio. By W. H. Knox. Pp. 1357-1361.
117. Current Supply Problems. By E. F. Dugger, G. L. Fugate and Marsden C. Smith. Pp. 1362-1366.

118. Importance of Salvage to the War Effort. By Clayton Grandy. Pp. 1367-1373.
119. Metallizing as a Method of Waterworks Maintenance. By C. E. Palmer. Pp. 1374-1380.
120. Conservation of Critical Materials in the Design of the South District, Chicago, Filtration Plant. By F. G. Gordon. Pp. 1381-1389.
121. Design of the Chemical Building of the South District Filtration Plant. By Paul Hansen. Pp. 1390-1396.
122. Chemical Treatment Plans for the South District Filtration Plant. By John R. Baylis. Pp. 1397-1404.
123. Efficiency Maintenance in Chicago Pumping Stations. By Frank J. McDonough, Paul Lippert and Julian M. Veggeberg. Pp. 1405-1414.
124. Effect of Sodium Hexametaphosphate on the Solution of Lead. By Edward W. Moore and Fred E. Smith. Pp. 1415-1424.
125. Stabilization of Lime Softened Water. By Charles P. Hoover. Pp. 1425-1454.

E *Engineering News-Record*
August 27

21. Charts Solve Multiple-Reservoir Problem. By Joseph A. Novoro. Pp. 64-65.

September 10

22. *c*. Lining Cast-Iron Pipe in Place. By Lewis H. Seton. Pp. 106-107.
23. *c*. New Aids for Water Well Drilling. P. 108.
24. Water Meter Testing on a Mass Production Basis. P. 109.

F *Water Works Engineering*
August 26

78. Water Treatment at Birmingham. By N. N. Wolpert. Pp. 986-988, 993.
79. Purifying Badly Polluted Water. By James F. Bartuska. Pp. 991-993.
80. *p*. Porous Plate Filter Underdrains. By E. E. Smith. Pp. 999-1001.
81. Relation of Water Streams to Effective Fire Protection. By A. C. Hutson. Pp. 1002-1004.

September 9

82. Honolulu Fights Water Rumors. By Charles E. Hogue. Pp. 1056-1058.
83. Bicycles for Meter Readers. By John E. Kleinhenz. Pp. 1059-1060.
84. Training for War Emergencies. By Horace J. Cook. Pp. 1061-1062.
85. Safeguarding Army Water Supplies. By Lloyd K. Clark. Pp. 1063-1065.
86. Effects of the War on the Waterworks Personnel. By Edward W. Frey and W. E. MacDonald. Pp. 1066-1067, 1122.
87. Guards for Water Works Property. A Symposium. Pp. 1068-1072, 1119.
88. Water Conservation Required to Meet War Demands. By Martin J. McLaughlin. Pp. 1075-1079, 1093.
89. New York City Conserves Its Water. By Patrick Quilty. Pp. 1080-1082.
90. Protecting Water Works at Night. By R. J. Swackhamer. Pp. 1083-1085, 1118.
91. History of Water Filtration. Pp. 1089-1090, 1118.

G *Water Works & Sewerage*
September

37. *p*. Role of Bacteria in Corrosion. By Arba H. Thomas. Pp. 367-372.
38. Water Supply and Sewerage Under Single Management. By Harold L. Brigham. P. 373.
39. Modern Storeyard and Garage Facilities. By Wendell R. La Rue. Pp. 374-377.
40. Effect of the War on Waterworks Operation in Canada. By Ross L. Dobbin. Pp. 388-389.
41. *p*. Metallizing. By C. E. Palmer. Pp. 391-396.
42. Aestheticism. Keeping Fresh Water Fresh. By D. R. Taylor. Pp. 397-398.

J *American City*
September

18. Watchdog Reduces Cost of Waterworks Protection. Pp. 42-43.
19. Cleaning and Sterilizing a Mill Water System. By P. A. Shaw. Pp. 60-61, 93.
20. *c*. An Underwater Crossing at Michigan City, Ind. P. 81.

K *Proceedings, Am. Soc. of Civil Engineers*
September

6. *t*. Entrainment of Air in Open Channel Flow at High Velocities. By L. Standish Hall. Pp. 1100-1140.
7. *t*. Entrainment of Air in Closed Conduit Flow. By A. A. Kalinske. Pp. 1141-1153.

L *Civil Engineering*
September

8. Water and Community Growth in Utah. By Ralf R. Woolley. Pp. 500-502.
9. Underflow Studies at Lake Issaqueena. By J. W. Johnson. Pp. 513-516.

M *Water and Sewage*
August

22. Systematic Program of Water Meter Testing and Repair. By Robert W. Ballantine and Francis Cunningham. Pp. 17-20, 51.
23. Protection of Waterworks Against Sabotage and Bomb Damage. Pp. 21-22.
24. *p*. Guarding Waterworks Property. By Warren J. Scott. Pp. 28, 58.

P *Public Works*
September

34. Fundamentals for Designing Low Dams. Pp. 14-16, 44-47.
35. *p*. Copper Sulphate for Aquatic Nuisances. Pp. 21, 47.
36. Water and Sewer Extensions for a Rapidly Growing Village. By Peter E. Brender. Pp. 22-23.
37. *n*. WPA Work for the St. Paul Water Department. P. 42.

Sewage treatment plant at Bagley, Minnesota.

The Sewerage Digest

Abstracts of the main features of all important articles dealing with sewerage and sewage treatment that appeared in the previous month's periodicals.

Chlorination for Odor Control

Sewage is chlorinated either to prevent the formation of sulfides or to destroy them after they have been formed. The latter requires more chlorine than the former. Experiments showed that a chlorine dosage equivalent to 5 to 10% of the demand does not retard sulfide production, but at least 20 to 25% should be satisfied to keep the sulfide content below 1 ppm for a period of 4 days; more, if longer periods of retardation are desired. Higher percentages may be necessary to offset effect of sludge deposits and side-wall slime in sewers; there are few data to indicate how much higher these should be.[G20*]

Steam Heating For Sludge Digestion

Los Angeles County, Calif., has been heating sludge in digestion tanks by use of live steam injected into the sludge instead of hot water pipes in the tank. A 70 hp boiler, utilizing sludge gas as fuel, supplies the steam. Raw sludge is transferred to two concentration tanks, combined with 20% digested sludge for seed. The mixture is then pumped to the digestion tanks, live steam being injected into the hopper from which it is drawn, raising the temperature to 90°—95°. The digestion tanks are not heated but their temperature remains between 85° and 90°. A 10° rise in temperature of raw sludge requires less than 1% added water in the form of steam.

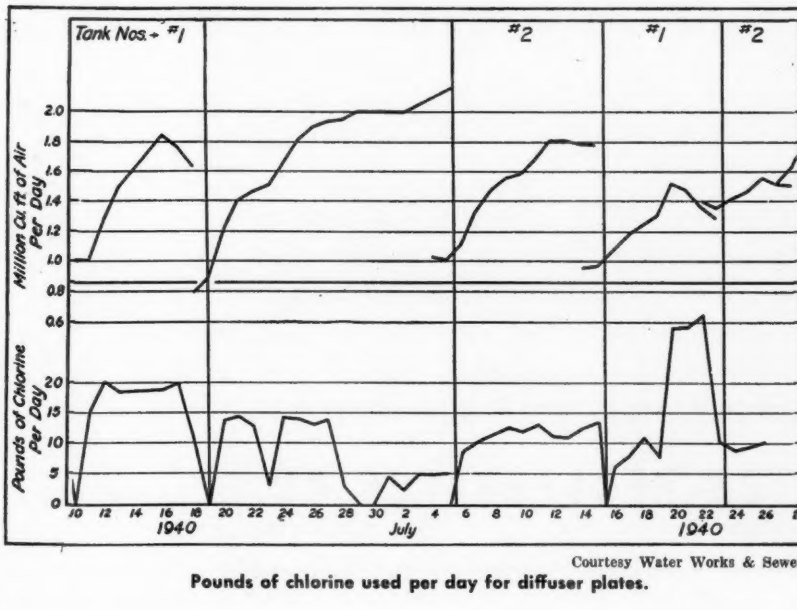
Disadvantages of the pipe system are cost of installing piping and of pumping circulating water; formation of scale on the pipes; inflexibility of operation; periodic dosing of cold sludge into a warm tank. Advantages of the steam method are ability to use any tank for digestion; temperature in the tank is not lowered intermittently by introduction of cold sludge. The heating makes no noticeable increase in odor.[G21*]

Chlorine for Diffuser Plates

At Jackson, Mich., after three years of operating four activated sludge tanks, the diffuser plates refused to pass the desired amount of air, even with raised pressure. Adding chlorine gas to the air header was tried; 20 pounds to one tank increased the air input from 700,000 cu. ft. to 1,000,000 cu. ft. per day, and 27 pounds the next day increased it to 1,400,000 cu. ft. But 13 days later it had fallen to 800,000 cu. ft. The chlorine was added for 17 days, at not over 15 lb. per day, and the air input increased to 2,160,000 cu. ft. Thirty-five days later it had dropped to 1,200,000 cu. ft. Meantime power consumption dropped from 600 kwh per million cu. ft. to 520. Experience has shown that adding chlorine at the rate of 4 lb. per hour for 2 or 3 hrs. gives maximum benefit per dollar of cost. When chlorine ceases to do much good, the plates are removed and given an acid bath.[G23]

Comparison of Sludge Disposal Methods

The joint plant of Rutherford and Carlstadt, N. J., contains two sludge digesters, two vacuum filters, a multiple-hearth incinerator, and 21 acres of ground, of which 4.3 acres is in grass, 4 is suitable for cultivation and 11 is swamp. The plant was designed for 4 mgd and is treating 2.4 mgd, much of which is industrial wastes. Sludge totals about 1500 dry tons a year. It is estimated that it would cost $7.00 per dry ton to filter and incinerate raw sludge, or $10,500 a year. Assuming digested sludge is 2/3 of the raw, filtering and incinerating this at $8 would cost $8,400 annually. Heat-drying of raw sludge would cost $15 per dry ton, and the product could be sold as fertilizer at $12, reducing net cost to $4,500 a year. This plan looks promising but fuel shortage prevents carrying it out; however, if 1/3 the sludge be so treated, gas for drying can be obtained by digesting the other 2/3, reducing the cost of drying to $13.40 a ton. Half the digested sludge (which would be reduced to about 640 tons) could be filtered and the other half used in liquid form on the 4 acres of land to grow crops. The 320 tons of digested sludge, filtered, would cost $6.00 a ton; half can be used on the lawn at the plant, the other half sold at cost. This gives a total cost of $2,460, or $1.65 per dry ton of raw sludge. This plan can be varied as costs, returns and other conditions vary.[H45]



Courtesy Water Works & Sewerage

Pounds of chlorine used per day for diffuser plates.

*See Bibliography in the September issue.

Operating Vacuum Filters

Instructions for operating the vacuum filters at the Chicago Southwest plant include the following: At each change of crews, see that the floats of the alarm system in the constant-head tanks are in proper working order. Keep overflow of conditioned sludge from these tanks at a mere trickle. If the vacuum on the filters in operation remains at 24" to 25" of mercury, it is reasonably certain that the sludge has been properly conditioned with ferric chloride; if it falls to 20"—22", too much ferric chloride is being used; if it rises to 26"—28", too little has been used. If the filter cake is thick and wet, the submergence is too great. If the filter output does not furnish sufficient load for the drying system, increase either the submergence or the speed of the filter. Flush the sludge venturi meter piezometer tubes daily. At the beginning of each shift speed up the sludge pumps for a very short time, then see that the speed is such as to maintain correct submergence of the filter. The chemist will furnish data every two hours for checking filter operation.[H44]

New York City's Sanitary Fills

During 1941 New York City disposed of 27,398,047 cubic yards of refuse, of which 9,025,450 were incinerated, 7,145,113 were taken to Riker's Island and 11,227,484 were disposed of in thirteen land fills. Since the land fill method was begun in 1937, over fifty million cubic yards have been disposed of in this way. The cost last year was 6.9 cts. per cu. yd. by land fill, compared to 23.1 cts. by incineration. An additional advantage is that the 50 million cu. yds. has been used to fill in 500 acres of swamps, marshes and tidal flats. The filled land is used for recreation areas, airports, army posts, etc. In grading the fill, a 30% shrinkage is allowed for. At the fill sites, 60-ton draglines and 20-ton bulldozers, both with crawler traction, are used; also road graders, crawler-traction dump wagons, dump trucks, one or two 10-ton tractors, and chemical spraying equipment. Material for covering the fill is obtained by excavating the area, sometimes as deep as 20 ft., before dumping begins. Six inches of cover is placed immediately, finally increased to a minimum of 2 feet.[L10]

Bibliography of Sewerage Literature

The articles in each magazine are numbered continuously throughout the year, beginning with our January issue.

c. Indicates construction article; *n*, note or short article; *p*, paper before a society (complete or abstract); *t*, technical article.

E *Engineering News-Record*
August 27

13. Neglected Items in Storm Sewer Design. By John Wilson. Pp. 74-75.

G *Water Works & Sewerage*
September

23. Maintaining Open Diffuser Plates With Chlorine. R. B. Jackson. Pp. 380-382.

H *Sewage Works Engineering*
September

44. Sludge Conditioning and Dewatering at Chicago Southwest. By Roy C. Hageman. Pp. 442-445.
45. Beating Sludge Disposal Costs by Diversification. By Albert B. Kozma. Pp. 446-447.
46. Activated Sludge Plant for Town of 7,500 Population. By H. I. Roberts. Pp. 448-450.
47. Sewage Treatment Plants in U. S. A. Pp. 451-454.

L *Civil Engineering*
September

10. Sanitary Land Fills in New York City. By Rolf Eliassen and Albert J. Lizee. Pp. 483-486.

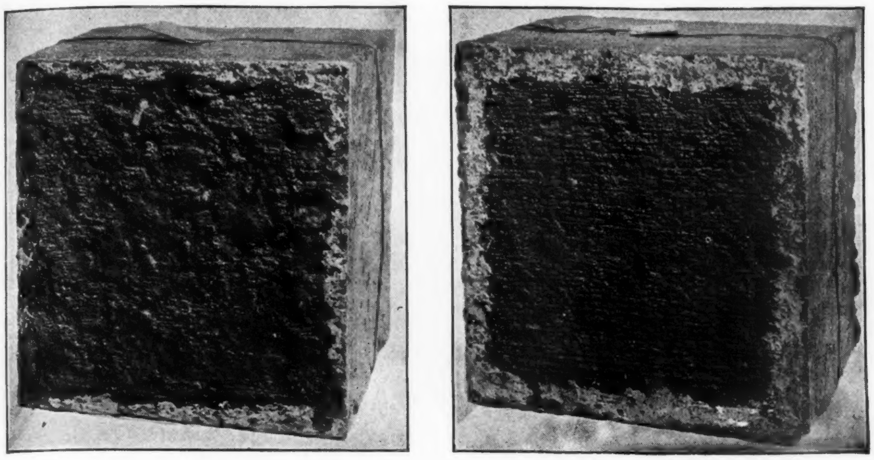
M *Water and Sewage*
August

6. Public Health Engineering in British Columbia. By R. Bowering. Pp. 23, 56.

P *Public Works*
September

27. Effect of Yeast on the Stabilization of Sewage and Sludge Digestion. By H. Heukelekian. Pp. 17-18.
28. Mosquito Control as a National Defense Measure. P. 18.
29. Operation and Maintenance of the Tifton, Ga., Sewage Plant. By D. H. Hurst. Pp. 27-28.
30. *n.* New London, O., Sewer System. P. 28.
31. *n.* Sewerage Maintenance Notes from Indianapolis, Ind. P. 43.

Keeping Up With New Equipment



PLAIN WITH HP-7

Effects of freezing and thawing on concrete slabs with and without HP-7.

Cement Dispersing Agent for Paving Concrete

The Master Builders Company
7016 Euclid Ave., Cleveland, Ohio

This company has recently placed on the market a cement dispersing and air entraining agent known as HP-7 which, when added to a paving mix, is claimed to improve all the essential qualities of concrete—transverse strength, resistance to wear, freedom from scaling. Furthermore, it appears that this is accomplished with little or no increase in cost, and in some cases with an actual reduction.

HP-7 is essentially a combination of an air-incorporating agent (sodium lauryl sulphate) with a cement dispersing agent (a derivative of lignin sulphonic acid).

Maximum dispersion of cement in the mix has long been recognized as necessary to the attainment of maximum strength and economy. The introduction of air, however, is a newer development which is not so generally known or understood. In fact it is actually contrary to the preconceived ideas of many people. Space does not permit discussion of this subject beyond the statement that small amounts of entrained air permit the use of lower water-cement ratios, reduce bleeding, and appear to add to the durability of the product—especially as regards scaling.

The manufacturer points out that as HP-7 is a mixture of definite compounds in definite proportion, its use is subject to perfect and complete control. It is noted also that while these ingredients can be used separately, and each is effective in its own way, it is only by the combination that the full beneficial effect is attained.

A 24-page pamphlet entitled, "Cement Dispersion and Air Entrainment in Concrete Pavement Construction," by Edward W. Scripture, Jr., Director of the Master Builders Research Laboratories, is available from the manufacturer. It contains a detailed and partly technical account of the character, development and use of HP-7 and of other products intended for the same ends; and includes reports of tests on various ordinary and special concretes at 3, 7 and 28 days.

Fire Pump for Civilian Defense and as Supplement for Fire Department

Ralph B. Carter Co.
Hackensack, N. J.

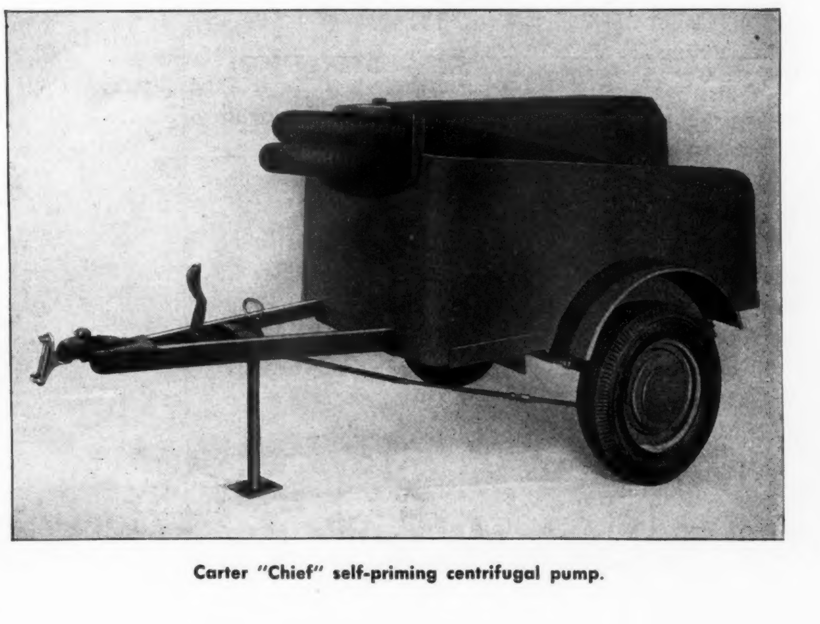
Carter "Chief" 500-Gallon Unit. Approved by National Board of Fire Underwriters. Pump: Carter self-priming single stage centrifugal pump. Capacity 500 G.P.M., 120-lb. pressure. Priming 100% automatic.

Engine: Carter Conversion Heavy Duty Industrial Truck Engine. Heat exchanger cooled. Develops 75 H.P. at 2400 R.P.M.

Starting: Self-starter, generator and heavy duty 17-plate storage battery.

Mounting: 2 steel disc wheels to take customer's 6.00 x 16 pneumatic tires. The pneumatic tires are not furnished by the manufacturer.

Hose Carrier: Arranged on each side of unit for carrying total of 500′ 2½″ fire hose and 2 12½′ lengths of 4″ suction hose. A limited number of Carter "Chiefs" are available for immediate delivery.



Carter "Chief" self-priming centrifugal pump.

Fibrex—Replaces Jute for Packing in Jointing B. & S. Pipe for Water and Sewer Mains

Hydraulic Development Corporation
50 Church St., New York, N. Y.

Dry Braided Fibrex, the manufacturer says, supplies a persistent demand by Sanitary Engineers for a packing which does not breed bacteria in water mains. Fibrex is a paper packing treated with a special water repellent which keeps it sterile and prevents it from disintegrating. It is a hard twisted core with a basket weave covering and packs in a joint exactly the same as braided jute.

Dry Braided Fibrex.

Laboratory tests made by Skinner &

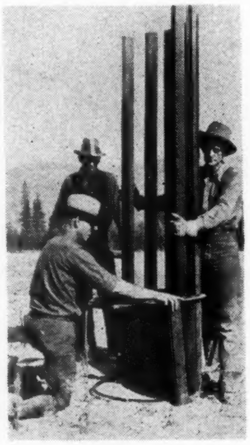
Sherman, Inc., Chemists and Engineers, Boston, Mass., show that Fibrex does not breed bacteria as is characteristic of jute in both sterile and contaminated water.

A 35-pound reel contains the same number of feet of Fibrex as a 50-pound reel of jute and sells at approximately the same price, thus reducing the cost for packing 30%.

Macpherson Patented Pressure Creosoted Wood Stave Pipe Culvert

Campbell-Conro Lumber Co.
Portland, Oregon

Macpherson Pressure Creosoted Wood Stave Pipe is a flexible type culvert designed to resist heavy variable external loads and eccentric load conditions. It is made up of wood staves and steel hoops, shipped in convenient size bundles to be assembled at the job site.


Assembly is started in upright position.

Interchangeability of staves allows one size "Standard" stave to be used in all sizes of pipe from 12" to 30", inclusive, and the "Jumbo" stave in all sizes of pipe, from 36" to 60". From a stock supply of staves and an assortment of hoop sizes, any size culvert within the range of 12" to 60" may be made up with these two stave patterns. Staves are cut to lengths of 2', 8' and 10', incised, branded and then creosoted.

The 2' staves are used in alternate runs in the ends of the pipe only, for "breaking joints" and for easy removal to lengthen pipe if later desired. The 8' and 10' staves make up the body of the pipe.

The method of treatment of the staves is the Boulton process (Boiling Under Vacuum) which extracts the moisture and creates a sterile condition in the wood, followed by pressing the creosote into the incised staves, thereby protecting the sterile wood by a deep penetration of creosote which repels attack by ground acids, termites and other wood destroying agencies.

The hoops are of 1½x1½x3/16" tee section steel, rolled to the desired diameter and fitted with lugs through which the bolt passes for tightening. After the hoops are fabricated they are treated with acid resisting asphalt impervious to moisture. Hoops are marked according to inside diameter of pipe for which they are intended, and bundled for convenience in handling.

Assembly of culvert units is very simple and is usually done by unskilled labor.

This culvert was first introduced in Canada and is said to have been used by every province of the Dominion of Canada during the last ten years.

Some of its uses are for culvert pipe

After laying started cylinder on ground, staves and hoops are added to complete desired length.

under highways, replacement of small bridges, cattle passes, irrigation systems, drainage systems in airports and agricultural areas, sewer systems, tapered staves to gradually increase diameter of pipe, perforated staves for subsurface drainage, half round flumes, ditch liners.

Macpherson Patented Wood Stave Culvert Pipe Units are being produced and distributed in the United States through the Campbell-Conro Lumber Company, Portland, Oregon, from whom license may be obtained for manufacture.

Army and Navy "E" Flag Awards

Barber-Greene Co.:

Barber-Greene Co., Aurora, Ill., for "Ahead of Schedule." Award was staged before a trainload of ditching, airport paving and other Barber-Greene construction equipment en route to "United Nations" bases throughout the world. Each of the shop and office employees were given a sterling silver "E" pin.

Builders-Providence, Inc.:

Builders Iron Foundry, Providence, R. I., was awarded the "E" Flag for production of war equipment including Venturi Meters and Control Instruments.

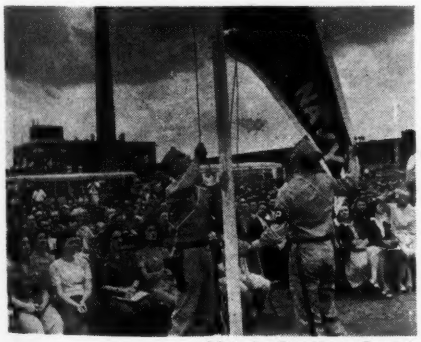


Photo by Providence Journal

Employees watch with pride, Pvt. Joseph Smolkowica and Sgt. Rollin Jones raise "Builders" Army and Navy "E" Flag.

Harry S. Chafee, Treasurer of the company, in accepting the award said in part, "The flag which has just been raised and the pins we are to receive are for work well begun. The Army and Navy, too, are now beginning their job of winning the war. But whatever the situation on the military front, our task is definitely established for us. It is production, more production and even more production."

Chain Belt Co.:

Robert P. Patterson, Under Secretary of War, in notifying the employees and management of Chain Belt Company that they would receive the Army-Navy "E" Production Award, wrote: "The men and women of Chain Belt Company are making an outstanding contribution to victory. Their practical patriotism stands as an example to all Americans, and they have reason to be proud of the record they have set."

Brig. Gen. A. G. Gillespie, Commandant of the Watervliet Arsenal, New York, spoke briefly at the ceremonies on the significance of the award. Hon. Julius P. Heil, Governor of Wisconsin, made the closing remarks.

Lone Star Cement Promotes Neylan and Oldham:

John F. Neylan has been elected Vice-President of Lone Star Cement Corporation in charge of sales to succeed Mr. H. C. Koch, retired. J. Bryan Oldham has been appointed General Sales Manager. Mr. Neylan has been associated with Lone Star Cement Corporation for 23 years and until his election as Vice-President occupied the position of General Sales Manager.

DIRECTORY OF CONSULTING ENGINEERS

Readers' Service Department

These booklets are FREE but distribution is restricted to those actively engaged in engineering or construction. Use the coupon below or write the manufacturer direct, mentioning PUBLIC WORKS.

Construction Materials and Equipment

Air Raid Shelters

3. New 8 page booklet pictures and describes a corrugated pipe shelter with gas tight end walls, emergency escape tunnel and other desirable features. Armco Drainage Products Assn., Middletown, Ohio.

Asphaltic Limestone

5. Characteristics, methods of laying, and results with cold lay mixture shipped ready to use. Especially adapted to resurfacing old pavements, sealcoats and airport runways. Alabama Asphaltic Limestone Co., Liberty Nat. Life Bldg., Birmingham, Ala.

Bridges

7. Teco Connectors, a new method of structural engineering, to spread the load on a timber joint more equally over the cross-section of the wood is described in new literature available from Timber Engineering Co., Inc., Dept. BS-2, 1319—18th St., N. W., Washington, D. C.

8. Lt.-weight, non-skid, mineral surfaced asphalt planks for any type bridge. Write for latest catalog. Servicised Products Corp., 6051 West 65th St., Chicago, Ill.

Cement Dispersion

9. "Economics of Cement Dispersion and Pozzolith" tells the complete story of how cement dispersion reduces water required up to 20% and increases workability 150%. Write The Master Builders Co., Cleveland, Ohio, for a copy.

10. A valuable treatise on available means of securing high strength, prevention of sealing, increased durability and improved wear resistance in concrete pavement construction. Master Builders Co., 7016 Euclid Ave., Cleveland, Ohio.

Cement, Early Strength

11. 64-page manual tells how to speed up year 'round concreting, shows how to secure high early strength and greater workability at temperatures either below or above freezing. Contains many actual examples of practical concreting operations; well illustrated with more than 60 photos, charts, graphs and tables. Calcium Chloride Assn., Penobscot Building, Detroit, Mich.

Cold Mix Plants

15. New catalog and prices of Portable Bituminous Mixers in 6 to 14 ft. sizes for resurfacing and maintenance. Issued by The Jaeger Machine Co., 400 Dublin Ave., Columbus, Ohio.

Concrete Accelerators

31. New 48-page booklet in five sections explains clearly the effects, advantages and methods of using Calcium Chloride and Portland Cement mixes. Complete and packed with practical information; well illustrated; pocket size. Sent free on request by Solvay Sales Corp., 40 Rector St., New York, N. Y.

33. Pocket manual of concrete curing with calcium chloride. Complete, handy. Contains useful tables, well illustrated. Write the Columbia Chemical Division, Pittsburgh Plate Glass Co., Grant Bldg., Pittsburgh, Pa.

Concrete Mixers

44. Catalog and prices of Concrete Mixers, both Tilting and Non-Tilt types, from 3½S to 56S sizes. The Jaeger Machine Company, 400 Dublin Ave., Columbus, Ohio.

Drainage Products

70. Standard corrugated pipe, perforated pipe and MULTI PLATE pipe and arches — for culverts, sewers, subdrains, cattlepasses and other uses are described in a 48-page catalog entitled "ARMCO Drainage Products," issued by the Armco Drainage Products Association, Middletown, Ohio, and its associated member companies. Ask for Catalog No. 12.

73. "Principles of Design of Airport Drainage" and other articles on airport drainage reprinted from PUBLIC WORKS Magazine are being distributed free by Bowerston Shale Co., Bowerston, O., Hancock Brick & Tile Co., Findlay, O., and Columbus Clay Mfg. Co., Blacklick, O. Address anyone of the above for a copy.

Graders, Patrol

105. The Austin-Western 99M Power Grader with its powerful all wheel drive simplifies all construction and maintenance; handles difficult jobs with economy and efficiency; and does better work on grading, ditching, scarifying, snow plowing, loading, mixing, bulldozing, shoulder trenching and backsloping. Write for Bulletin 1946. Austin-Western Road Machinery Co., Aurora, Ill.

Mud-Jack Method

107. How the Mud Jack Method for raising concrete curb, gutter, walls and street solves problems of that kind quickly and economically without the usual cost of time-consuming reconstruction activities — a new bulletin by Koehring Company, 3026 West Concordia Ave., Milwaukee, Wis.

Oil

109. Ring-Free Motor Oil that keeps motors clean and free from carbon, and reduces frequency of overhauls is described in literature available from Macmillan Petroleum Corp., 530 West 6th St., Los Angeles, Calif.

Paving Materials, Bituminous

111. New "Tarvia Manual" is packed with useful data on how to build and maintain roads with Tarvia. Each step is illustrated with excellent action pictures. 64 pp. 103 ills. Write to The Barrett Div., 40 Rector St., New York, N. Y.

Pumps

120. Interesting new booklet tells how to lengthen the life of your pumps. Explains how a little care will save a lot of wear. Write today for your copy. Homelite Corp., 2403 Riverdale Ave., Portchester, N. Y.

121. New illustrated catalog and prices of Jaeger Sure Prime Pumps, 2" to 10" sizes, 7000 to 220,000 G.P.H. capacities, also Jetting, Caisson, Road Pumps, recently issued by The Jaeger Machine Company, 400 Dublin Ave., Columbus, Ohio.

123. New brochure by Gorman-Rupp Co., Mansfield, Ohio, illustrates and describes many of the pumps in their complete line. Covers heavy duty and standard duty self-priming centrifugals, jetting pumps, well point pumps, triplex road pumps and the lightweight pumps.

124. 16-page illustrated bulletin, SP-37, describes and illustrates complete C. H. & E. line of self-priming centrifugal pumps from ½" to 8", including lightweight models for easy portability. C. H. & E. Mfg. Co., 3841 No. Palmer St., Milwaukee, Wis.

Road Building and Maintenance

128. Motor Patrol Graders for road maintenance, road widening and road building, a complete line offering choice of weight, power, final drive and special equipment to exactly fit the job. Action pictures and full details are in catalogs Nos. 253, 254 & 255, issued by Galion Iron Works & Mfg. Co., Galion, Ohio.

Rollers

133. New Tu-Ton roller of simple construction for use in rolling sidewalks along highways, playgrounds and other types of light rolling is fully described in a bulletin issued by C. H. & E. Mfg. Co., 3841 No. Palmer St., Milwaukee, Wis.

138. "The Buffalo-Springfield line of road rollers (tandem, 3-wheel, and 3-axle) are described in the latest catalog issued by the Buffalo-Springfield Roller Co., Springfield, Ohio."

139. "Ironeroller" 3 Axle Roller for extra smooth surfaces on all bituminous work. Booklet contains roller data and operation details. Hercules Co., Marion, Ohio.

140. This well-illustrated 16-page catalog describes the tandem, autocrat, cadet, and roll-a-plane rollers, and explains what each is intended to accomplish. Write Austin-Western Road Mach. Co., Aurora, Ill.

Rotproofing

145. Cuprinol, a rotproofing chemical that protects wood from fungi and insects, yet has no offensive odor, is non-poisonous, does not corrode metal and can be painted over. Get full details in booklet from Cuprinol, Inc., 7 Water St., Boston, Mass.

Soil Stabilization

150. "High-Service, Low Cost Roads" is one of the newer booklets using an effective combination of picture and text to set forth the principles and advantages of road surface stabilization with calcium chloride. Complete, interesting and well illustrated. 34 pages. Sent by Solvay Sales Corp., 40 Rector St., New York, N. Y.

152. The Columbia Chemical Division will be glad to furnish to anyone interested complete information dealing with Calcium Chloride Stabilized Roads. This literature contains many charts, tables and useful information and can be obtained by writing Columbia Chemical Div., Pittsburgh Plate Glass Co., Grant Bldg., Pittsburgh, Pa.

154. "Soil Stabilization with Tarvia" —An illustrated booklet describing The steps in the stabilization of roadway soil with Tarvia will be mailed on request by The Barrett Div., 40 Rector St., New York, N. Y.

USE THIS COUPON

Readers' Service Dept., PUBLIC WORKS 10-42
310 East 45th St., NEW YORK

Please send me without obligation the following booklets listed in your READERS' SERVICE SECTION ....
(indicate by numbers)

Name ....

Occupation ....

Street ....

City .... State ....

Spreader

187. Jaeger Paving equipment, including Mix-in-Place Roadbuilders, Bituminous Pavers, Concrete Bituminous Finishers, Adjustable Spreaders, Forms, etc.—4 complete catalogs of latest equipment in one cover, issued by The Jaeger Machine Company, 400 Dublin Ave., Columbus, Ohio.

Surface Consolidation and Maintenance

188. Detailed and illustrated presentation of the method and procedure in consolidated operations; explains how sub-soils can be conditioned to resist softening and frost action; how surfacing can be consolidated to provide smooth all-weather riding surfaces; how they can be maintained so as to prevent disintegration and gravel loss. Write the Calcium Chloride Association, Penobscot Bldg., Detroit, Mich., for Bulletin No. 29.

Timber Structures

189. "Typical Designs of Timber Structures" contains plans for 45 representative structures that have been engineered with Teco Connectors. For free copy write Timber Engineering Co., Inc., Room 6GG, 1319—18th St., N. W., Washington, D. C.

Street and Paving Maintenance

190. "Blacktop Road Maintenance and Construction Equipment" — Asphalt and tar kettles, flue type kettles, spray attachments with completely submerged pumps, tool heaters, surface heaters, road brooms, portable trail-o-rollers, etc. These are all described in detail and illustrated. This modern and up-to-date equipment for blacktop airport and road construction and maintenance is based upon experience and engineering research over a period of 42 years. Write for Catalog R. Littleford Bros., Inc., 452 East Pearl St., Cincinnati, O.

198. Illustrated Bulletins 15 to 20 describe Mohawk Oil Burning Torches; "Hotstuf" Tar and Asphalt Heaters; Portable Trailer Tool Boxes; Pouring Pots and other equipment for street and highway maintenance, roofing, pipe coating, water proofing, etc. Mohawk Asphalt Heater Co., Frankfort, N. Y.

Snow Fighting

Snow Plows

350. "Frink One-Way Sno-Plows" is a four page catalog illustrating and describing 5 models of One-Way Blade Type Sno-Plows for motor trucks from 1½ up to 8 tons capacity. Interchangeable with V Sno-Plow. Features, specifications and method of attaching. Carl H. Frink, Mfr., Clayton, 1000 Islands, N. Y.

Ice Control

351. "Make Icy Highways Safe for Traffic"—a new bulletin by Michigan Alkali Co., Ford Bldg., Detroit, Mich., tells how to use calcium chloride for modern ice control.

Sanitary Engineering

Aero-Filter

356. "Results Produced by Aero-Filters" is a new pamphlet covering results at Temple, Texas; Paris, Ill.; Webster City, Iowa; and Mason, Mich. Write Lakeside Engineering Corp., 222 West Adams St., Chicago, Ill.

Air Release Valves

357. Automatic Air Release Valves for water, sewage and industrial uses are described and illustrated in new catalog issued by Simplex Valve & Meter Co., 6750 Upland St., Philadelphia, Pa.

Analysis of Water

360. "Methods of Analyzing Water for Municipal and Industrial Use" is an excellent 94 page booklet with many useful tables and formulas. Sent on request by Solvay Sales Corp., 40 Rector St., New York, N. Y.

Activation and Aeration

376. A valuable booklet on porous diffuser plates and tubes for sewage treatment plants. Covers permeability, porosity, pore size and pressure loss data, with curves. Also information on installations, with sketches and pictures, specifications, methods of cleaning and studies in permeability. 20 pp. illustrated. Sent on request to Norton Company, Worcester, Mass.

377. Activated Sludge Treatment. Five booklets are available covering Stationary Diffuser Tubes, the Swing Diffuser, the Mechanical Aerator and the Combination Aerator and Clarifier. Operation of activated sludge plants. Chicago Pump Co., 2336 Wolfram St., Chicago, Ill.

Chlorinators, Portable

380. Complete data on new portable chlorinator designed to meet emergency calls quickly and efficiently. Write Wallace & Tiernan Co., Inc., Newark, N. J.

381. "Emergency Sterilization Equipment," a new bulletin describing the advantages of Dual Drive Chlor-O-Feeders which can serve as either a permanent chemical feeder or as a portable emergency chlorinator. Order from Proportioneers, Inc., 96 Codding St., Providence, R. I.

Cleaning Mains

382. "Let's Look Into the Matter of Water Main Cleaning" is an illustrated booklet outlining the advantages of water main cleaning and explains how it can be done quickly and inexpensively by The National Method. Write National Water Main Cleaning Co., 30 Church St., New York, N. Y.

Cleaning Sewers With Own Forces

383. A 20-page booklet describes and illustrates a full line of sewer cleaning equipment—Rods, Root Cutters, Buckets, Nozzles and Flushers. Write W. H. Stewart (Pioneer Mfr. since 1901), Jacksonville, Fla., or P. O. Box 767, Syracuse, N. Y.

Consulting Engineers

385. "Who, What, Why" outlines briefly the functions of the consulting chemist and chemical engineer. Covers various methods of cooperation, on different types of problems, with industry, with attorneys and with individuals. Foster D. Snell, Inc., 305 Washington St., Brooklyn, N. Y., will send a copy on request.

Feeders, Chlorine, Amonia and Chemical

387. For chlorinating water supplies, sewage plants, swimming pools and feeding practically any chemical used in sanitation treatment of water and sewage. Flow of water controls dosage of chemical; reagent feed is immediately adjustable. Starts and stops automatically. Literature from % Proportioneers, Inc. % 96 Codding St., Providence, R. I.

Filters

388. Anthrafilt for increasing filter capacity without adding filters. For full details write H. G. Turner, State College, Pa.

Fire Hydrants

390. Specifications for standard AWWA fire hydrants with helpful instructions for ordering, installing, repairing, lengthening and using. Issued by M & H Valve & Fittings Co., Anniston, Ala.

391. See listing No. 410.

Flow Meters

392. The primary devices for flow measurement—the orifice, the pilot tube, the venturi meter and others—and the application to them of the Simplex meter are described in a useful 24-page booklet (42A). Simplex Valve and Meter Co., 6750 Upland St., Philadelphia, Pa.

Gas Holders and Digesters

393. Clarifiers, sludge digesters and other tanks and gas holders for sludge gas. Graver Tank & Mfg. Co., Inc., East Chicago, Ind.

Gates, Valves, Hydrants

394. Gate, flap and check valves; floor stands and fittings. New catalog No. 34 gives detail information with dimensions for all types of new full line. M. & H. Valve & Fittings Co., Anniston, Ala.

395. Complete booklet with much worthwhile water works data describes fully Ludlow hydrants and valves. Sent on request. Ludlow Valve Mfg. Co., Troy, N. Y.

396. See listing No. 410.

Gauges

398. The full line of Simplex gauges for filtration plants are illustrated and described in catalog issued by Simplex Valve and Meter Co., 6750 Upland St., Philadelphia, Pa.

Lubricants

401. Lubricants. "Lubriplate," a combined lubricant and protection against corrosion, especially effective for parts immersed in sewage. An 8-page folder. Fiske Brothers Refining Co., Newark, N. J.

Laboratory Equipment

402. Acid-proof sinks, pipes, ventilating and other equipment. Maurice A. Knight, Akron, Ohio.

403. pH and Chlorine Control. A discussion of pH control and description of comparators, chlorimeters and similar devices. An 80-page booklet. W. A. Taylor & Co., 7301 York Road, Baltimore, Md.

Manhole Covers and Inlets

405. Street, sewer and water castings in various styles, sizes and weights. Manhole covers, water meter covers, adjustable curb inlets, gutter crossing plates, valve and lamphole covers, ventilators, etc. Described in catalog issued by South Bend Foundry Co., Lafayette Boul. and Indiana Ave., South Bend, Ind.

Meters, Venturi

406. New bulletin illustrates Builders Air Relay system of transmission for the Venturi Meter which is particularly useful for liquids containing suspended solids like sewage. Eliminates corroson, clogged pipes, etc. Write Builders-Providence, Inc., Codding St., Providence, R. I.

Mixers, Chemical

407. Chemical Mixers. "Slo-Mixers" for multi-stage flocculation described and illustrated in 6-page bulletin No. 389. Chain Belt Co., 1663 W. Bruce St., Milwaukee, Wis.

Pipe, Cast Iron

408. Handbook of Universal Cast Iron Pipe and Fittings, pocket size, 104 pages, illustrated, including 14 pages of useful reference tables and data. Sent by The Central Foundry Co., 386 Fourth Ave., New York, N. Y.

409. Cast iron pipe and fittings for water, gas, sewer and industrial service. Super-deLavaud centrifugally-cast and pit-cast pipe. Bell-and-spigot, U. S. Joint, flanged or flexible joints can be furnished to suit requirements. Write U. S. Pipe and Foundry Co., Burlington, N. J.

410. "Cast Iron Pipe and Fittings" is a well illustrated 44 page catalog giving full specifications for their complete line of Sand Spun Centrifugal Pipe, Fire Hydrants, Gate Valves, Special Castings, etc. Will be sent promptly by R. D. Wood Co., 400 Chestnut St., Philadelphia, Pa.

Pipe, Transite

414. Two new illustrated booklets, "Transite Pressure Pipe" and "Transite Sewer Pipe" deal with methods of cutting costs of installation and maintenance of pipe lines and summarize advantages resulting from use of Transite pipes. Sent promptly by Johns-Manville Corp., 22 East 40th St., New York, N. Y.

Pipe Joints, Sewer

415. How to make a perfect sewer pipe joint—tight, prevents roots entering sewer, keeps lengths perfectly aligned; can be laid with water in trench or pipe. General instructions issued by L. A. Weston, Adams, Mass.

Pipe, 2-inch Cast Iron

417. Generously illustrated booklet describes McWane 2-inch cast iron pipe and its manufacture in streamlined pipe shop. Write McWane Cast Iron Pipe Co., Birmingham, Ala.

Protection for Plants

419. Protecting sewage plants against disintegration. What to use and where to use it. Complete data with labels. Inertol Co., Inc., 470 Frelinghuysen Ave., Newark, N. J.

Pumps and Well Water Systems

420. Installation views and sectional scenes on Layne Vertical Centrifugal and Vertical Turbine Pumps fully illustrated and including useful engineering data section. Layne Shutter Screens for Gravel Wall Wells. Write for descriptive booklets. Advertising Dept., Layne & Bowler, Inc., Box 186, Hollywood Station, Memphis, Tenn.

Meter Setting and Testing

430. The most complete catalog we have seen on setting and testing equipment for water meters—exquisitely printed and illustrated 48-page booklet you should have a copy of. Ask Ford Meter Box Co., Wabash, Ind.

Reservoirs, Concrete

431. Data on how large reservoirs may be built at a saving as units by the Wm. S. Hewett System of reinforced concrete construction will be sent without obligation. The Wm. S. Hewett System, 20 N. Wacker Dr., Chicago, Ill.

Screens

434. Be assured of uninterrupted, constant automatic removal of screenings. Folder 1587 tells how. Gives some of the outstanding advantages of "Straightline Bar Screens" (Vertical and Inclined types). Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill.

Sludge Drying and Incineration

440. "Disposal of Municipal Refuse." Complete specifications and description including suggested form of proposal; form of guarantees; statements and approval sheet for comparing bids with diagramatic outline of various plant designs. 48 pages. Address: Morse Boulger Destructor Co., 216-P East 45th St., New York, N. Y.

442. Recuperator tubes made from Silicon Carbide and "Fireclay" Corebusters for maximum efficiency are described and illustrated in bulletin No. 11 issued by Fitch Recuperator Co., Plainfield National Bank Bldg., Plainfield, N. J.

443. Nichols Herreshoff incinerator for complete disposal of sewage solids and industrial wastes—a new booklet illustrates and explains how this Nichols incinerator works. Pictures recent installations. Write Nichols Engineering and Research Corp., 60 Wall Tower, New York, N. Y.

Softening

444. This folder explains the process of Zeolite water softening and describes and illustrates the full line of equipment for that purpose made by the Graver Tank & Mfg. Co., 4809-15 Tod Ave., East Chicago, Ind. Write for a copy of this instructive folder.

Sprinkling Filters

445. Design data on sprinkling filters of Separate Nozzle Field and Common Nozzle Field design as well as complete data on single and twin dosing tanks, and the various siphons used in them, for apportioning sewage to nozzles. Many timesaving charts and tables. Write Pacific Flush Tank Co., 4241 Ravenswood Ave., Chicago, Ill.

Swimming Pools

446. Data and complete information on swimming pool filters and recirculation plants; also on water filters and filtration equipment. For data prices, plans, etc., write Roberts Filter Mfg. Co., 640 Columbia Ave., Darby, Pa.

Taste and Odor Control

449. "Taste and Odor Control in Water Purification" is an excellent 92-page, illustrated booklet covering sources of taste and odor pollution in water supplies and outlining the various methods of treatment now in use. Every water works department should have a copy. Write Industrial Chemical Sales Div., 230 Park Ave., New York, N. Y.

450. Technical pub. No. 207 issued by Wallace & Tiernan Co., Inc., Newark, N. J., describes in detail taste and odor control of water with BREAK-POINT Chlorination, a method of discovering the point at which many causes of taste may be removed by chlorination with little or no increase in residual chlorine. Sent free to any operator requesting it.

451. Powdered Hydrodarco for taste and odor control. For complete data on its use write Darco Corp., 60 East 42nd St., New York, N. Y.

Treatment

453. "Safe Sanitation for a Nation," an interesting booklet containing thumbnail descriptions of the different pieces of P.F.T. equipment for sewage treatment. Includes photos of various installations and complete list of literature available from this company. Write Pacific Flush Tank Co., 4241 Ravenswood Ave., Chicago, Ill.

454. A full line of equipment for sewage disposal including clarifiers, chemical treatment plants, rotary distributors, gas holders and many other pieces of equipment are described in a new bulletin just issued by Graver Tank & Mfg. Co., 4809-15 Tod Ave., East Chicago, Ind.

455. New booklet (No. 1642 on Link-Belt Circuline Collectors for Settling Tanks contains excellent pictures; drawings of installations, sanitary engineering data and design details. Link-Belt Company, 2045 W. Hunting Park Ave., Philadelphia.

456. New 16-page illustrated catalog No. 1742 on Straightline Collectors for the efficient, continuous removal of sludge from rectangular tanks at sewerage and water plants. Contains layout drawings, installation pictures, and capacity tables. Address Link-Belt Co., 2045 West Hunting Park Ave., Philadelphia, Pa.

457. New illustrated folder (1942) on Straightline apparatus for the removal and washing of grit and detritus from rectangular grit chambers. Address: Link-Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.

458. "Sedimentation with Dorr Clarifiers" is a complete 36-page illustrated catalog with useful design data. Ask The Dorr Company, 570 Lexington Ave., New York, N. Y.

459. A combination mechanical clarifier and mechanical digester, The Dorr Clarigester, is explained and illustrated in a bulletin issued by The Dorr Company, 570 Lexington Ave., New York, N. Y.

460. Comminutor. Booklet describes comminutor which acts as sewage screen and cuts up floating solids in the sewage. Design details, tables and blueprints. Chicago Pump Co., 2336 Wolfram St., Chicago, Ill.

461. Preflocculation without chemicals with the Dorrco Clariflocculator in a single structure is the subject of a new booklet issued by The Dorr Company, 570 Lexington Ave., New York, N. Y.

462. Dorrco Monorake for existing rectangular sedimentation tanks, open or closed, is described and illustrated in a new catalog sent on request. The Dorr Co., 570 Lexington Ave., New York, N. Y.

463. Clarifiers and Digesters. Circular and rectangular clarifiers and dome roof digesters are described in a new catalog. Hardinge Co., Inc., York, Pa.

464. Rotary Distributors. Bulletin describes Infilco rotary distributors and automatic dosing siphons. Infilco, Inc., 325 W. 25th Place, Chicago, Ill.

465. Grit Washers and Collectors, by Jeffrey are built in three types: scraper, V-bucket and combination. For full details ask for Jeffrey Catalog No. 703-A. Jeffrey Mfg. Co., 948-99 No. Fourth St., Columbus, Ohio.

466. Flocculation with Floctrols. For details on controlled flocculation, tapered mixing, practical elimination of short circuiting, rapid settling of properly flocculated solds write for Catalog No. 703-A. Jeffrey Mfg. Co., 948-99 No. Fourth St., Columbus, Ohio.

467. Sludge Removers and Mixers. Chain and scraper sludge collectors; Tow-Bro/sludge removers; and Rex Slo-Mixers and flash mixers for multi-stage flocculation. (Just out.) Chain Belt Co., 1679 W. Bruce St., Milwaukee, Wis.

Valves (See Gates, Air Release, etc.)

Waste Elimination

469. Full information on the Pitometer Survey—a complete check-up on your water plant to reveal hidden sources of waste—will be sent promptly by The Pitometer Co., 48 Church St., New York, N. Y.

Water Treatment

470. If you have a water conditioning problem of any kind, write Graver Tank & Mfg. Co., Inc., 4809—15 Tod Ave., East Chicago, Ind., who manufacture all types of conditioning equipment and will be pleased to make recommendations.

471. Lime specifications and full impartial data on water treatment with lime may be obtained from National Lime Assn., 927 Fifteenth St., N. W., Washington, D. C.

472. Bulletin describes stabilizing lime-softened water by recarbonation, discussing gas production, washing, compressing, drying, and applying the CO(2). Infilco, Inc., 325 West 25th Place, Chicago, Ill.

473. Water Softening. The use of the Spaulding Precipitator to obtain maximum efficiency and economy in water softening is described in a technical booklet. Permutit Co., 330 W. 42nd St., New York, N. Y.

Water Works Operating Practices

490. "Important Factors in Coagulation" is an excellent review with bibliography and outlines of latest work done in the field. Written by Burton W. Graham and sent free on request to Stuart-Brumley Corp., 516 No. Charles St., Baltimore, Md.

Water Service Devices

500. Data on anti-freeze outdoor drinking fountains, hydrants, street washers, etc., will be sent promptly on request to Murdock Mfg. & Supply Co., 426 Plum St., Cincinnati, Ohio.

New Appointments

New City and County Appointments Recently Reported:

City Engineers

C. L. Baylor, Downers Grove, Ill.
William Pyle, Jr., Oskaloosa, Iowa.
C. H. Storms, Laurel, Mont.
Arthur Brokaw, North Arlington, N. J.
C. D. Peterson, Amsterdam, N. Y.
Dean G. Edwards, New York, N. Y.
Thomas H. Sauter, Cuyahoga Falls, Ohio.

City Managers

Earl R. Weeber, East Grand Rapids, Mich.
E. L. Wilson, Excelsior Springs, Mo.
Wyly Keith, Atoka, Okla.
J. J. Rauch, Rock Hill, S. C.
John P. Hoffman, Two Rivers, Wis.

Supt. Public Works

Louis Anslyn, Zion, Ill.

Water Works Superintendents

M. C. Turner, Conway, Ark.
J. A. Wallis, Malvern, Ark.
Lloyd H. Lutz, Ocala, Fla.
M. A. Stearns, Kokomo, Ind.
B. L. Bunker, Oskaloosa, Iowa.
John T. Feix, Cynthiana, Ky.
H. K. Hines, Frankfort, Ky.
Harry Stewart, Providence, Ky.
P. W. Long, Shelbyville, Ky.
Stanley Noel, North Adams, Mass.
Tip H. Allen, Canton, Miss.
John F. Sanders, Boonville, Mo.
R. E. Wooten, Dunn, N. C.
B. E. Lancaster, Roanoke Rapids, N. C.
Clyde Ratliff, Wadesboro, N. C.
T. A. Stout, McDonald, Pa.
Oscar Nelson, Rice Lake, Wis.

County Engineers

Ben Anderson, Moffatt Co., Craig, Colo.
H. J. Friedman, Glynn Co., Brunswick, Ga.
Ray Spicer, McDonough Co., Macomb, Ill.
E. T. Martin, Cass Co., Atlantic, Ia.
William Henschen, Hancock Co., Garner, Ia.
John Cullison, Rawlins Co. (Acting), Atwood, Kan.
J. C. Adams, Kittson Co., Hallock, Minn.
Victor L. Hoke, Otsego Co., Cooperstown, N. Y.
Carl H. Bauer, Montgomery Co., Dayton,, Ohio.
J. W. Gentry, Hamilton Co., Chattanooga, Tenn.
J. A. Ellis, Hockley Co., Levelland, Tex.
Lester M. Corey, Pierce Co., Tacoma, Wash.

Conventions and Association Meetings

Oct. 18-21—American Public Works Association's Annual Convention, Hotel Statler, Cleveland, Ohio.

Oct. 22-24—Federation of Sewage Works Association's Annual Convention, Hotel Statler, Cleveland, Ohio.

Oct. 27-30—American Public Health Association's Annual Meeting, Municipal Auditorium, St. Louis, Mo.

Oct. 28-30—California Section, A.W.W.A., meets at Oakland Hotel, Oakland, Calif.

Nov. 2-4—North Carolina Section, A.W.W.A., Washington-Duke Hotel, Durham, N. C.

Dec. 2-4—Highway Research Board will hold annual meeting in Hotel Statler, St. Louis, Mo.

William E. Clow, Chairman, James B. Clow & Sons, Dies

Born September 23, 1860, at Industry, Pennsylvania. Died September 14, 1942, at Chicago, Illinois. With his father, Captain James Beach Clow, William E. Clow, at the age of 18 years, formed a partnership and started the new firm under the name of James B. Clow & Son. Later—as brothers of William, Charles R., Harry B., and James C., entered the company—the name of the firm was changed to James B. Clow & Sons.

ADVERTISERS

IN THIS ISSUE